Assessment of the Aquatic Effects of Mining in Canada:

AQUAMIN

Supporting Document II: Eastern Canadian Shield, Ontario

Case Studies

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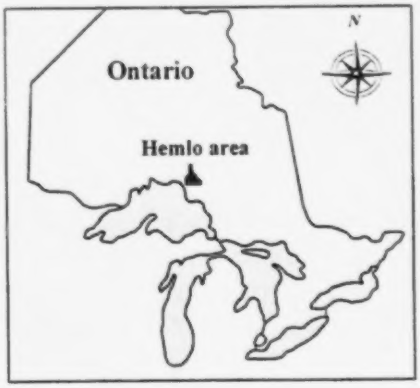
1 Hemlo Area

1.1 Site Description

1.1.1 General Mine Site Description

The Hemlo Camp, comprised of Golden Giant Mine owned by Hemlo Gold Mines Inc., David Bell Mine, Teck Corona Operating Corporation and Williams Mine, Williams Operating Corporation both owned jointly by Teck Corporation and Homestake Canada Inc., is located in the district of Thunder Bay in Bombay Township. The site is located next to Highway 17 approximately 430 km west of Sault Ste. Marie and 387 km east of Thunder Bay. The nearest municipality is the town of Marathon which is 37 km west of the Hemlo Camp (Figure 1.1).

Figure 1.1: Location of Hemlo area



The mines have a permit to operate Theresa Lake as a water reservoir for the purpose of obtaining raw water from Cedar Creek. There are three lake within this watershed which are used for recreational purposes, two of which have cottage development. The only industrial discharge operation close to the mines is an explosives plant and magazine site. The property is leased from the Golden Giant Mine. This neighbour has no affect on the effluent discharges from the Hemlo mines.

The three Hemlo operations are very close in proximity, which has resulted in areas of shared responsibilities. The Williams Mine and David Bell Mine are now owned by the same corporate companies. This ownership has resulted in a shared tailings basin which was originally constructed with a separator dam dividing Molson Lake in two. The two operations share a common tailings facility but operate separate effluent treatment plants which discharge effluent to separate head waters. The David Bell effluent treatment plant (ETP) is located beside their mill with the mill tailings and treated effluent being pumped through a pipe to the tailings site approximately 4 km away. The David Bell effluent is discharged to Lim Lake. Williams Mine ETP is located on the south west end of the combined tailings basin. The treated effluent is pumped an additional 2 km to Frank lake. Both receiving water bodies eventually drain into the White river (Figure 1.2).

Golden Giant Mine's tailing basin is located adjacent to the minesite with the ETP in close proximity. However, the effluent discharge is pumped approximately 5 km to the south to discharge into Lim lake. Golden Giant Mine and David Bell Mine share the same receiving water body.

Upon closure of the Hemlo camp properties the overflow from the Williams/David Bell tailings basin will be reporting to Lee Lake. The overflow from the Golden Giant tailings pond will report to Cedar Creek.

1.1.2 History

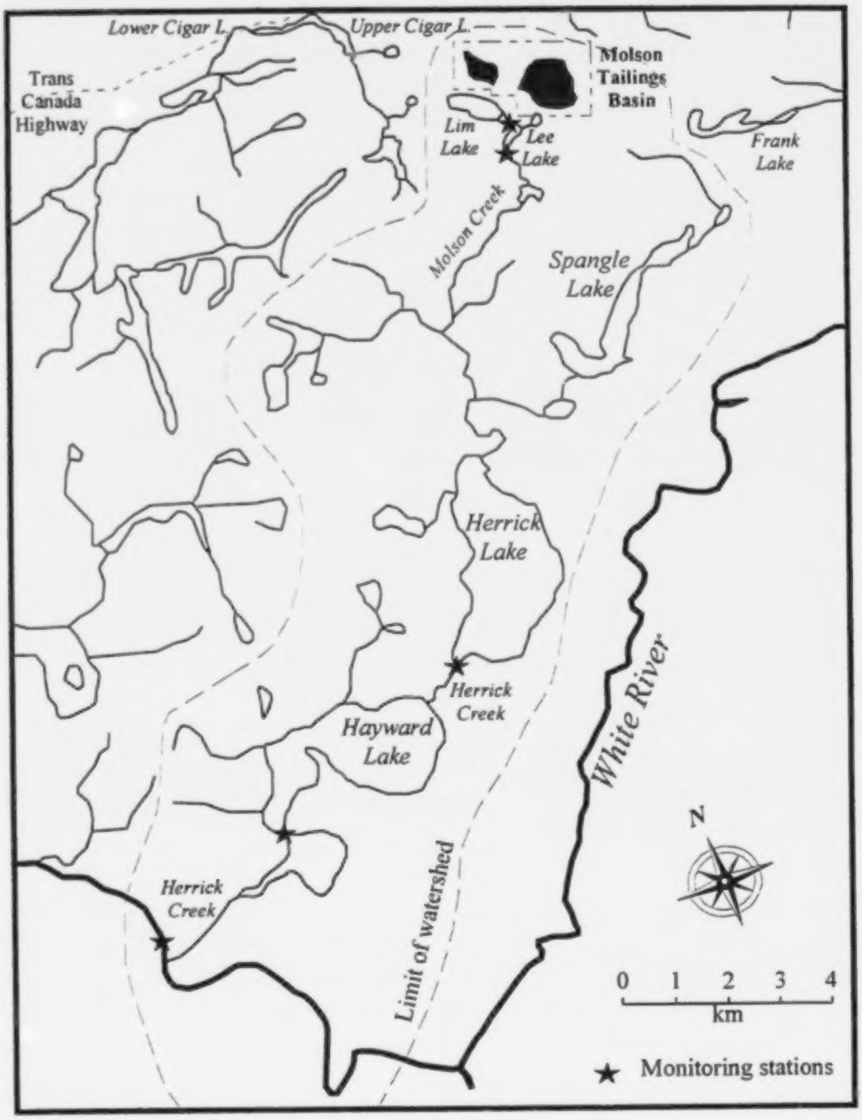
Gold mineralization was discovered in the Hemlo area in 1944. A year later, 11 claims were staked and subsequently patented by the late Dr. Jack Kerr William. Drilling on claims which later developed into the David Bell Mine started early in 1981 and intersected the Hemlo ore body in May of that year. A drilling program on the Williams property discovered the Williams ore body in March 1982. Previous to the mining operations the property was crown land with no apparent influences other than railway and highway thoroughfares.

1.1.3 Geology

The general mine area is underlain by rocks of the Heron Bay Group of the White River Greenstone Belt. The Heron Bay Group of Archean-aged metamorphosed sedimentary and volcanic rocks dips north and contains felsic to mafic sills. The entire package is cut by late North-South trending subvertical diabase and lamprophyre dyking and has been regionally metamorphosed up to the lower Amphibolite grade.

The metasedimentary rocks comprise a poorly to rhythmically layered greywacke while the metavolcanic rocks vary from felsic to mafic in composition. The volcanic package includes

Figure 1.2: Surface water drainage in the Hemlo area, showing locations of water quality monitoring stations


Lower Cigar L.
Upper Cigar L.
Trans Canada Highway
Molson Tailings Basin
Lim Lake
Lee Lake
Frank Lake
Molson Creek
Spangle Lake
Herrick Lake
Herrick Creek
Hayward Lake
Herrick Creek
White River
Limit of watershed
N
0 1 2 3 4
km
★ Monitoring stations

both intrusive and volcanoclastic extrusive rocks.

The soil profile includes a thin layer of humus with the A and B soil horizons developed in the top meter of the till stratigraphy. The humus is a several centimetre thick layer of moss of forest litter. The soil profile is generally expressed as an oxidation of the till layer. A one half meter thick non-calcareous basal till made up of local shield material generally overlies bedrock. This till is overlain by a one to several meter thick calcareous till. The calcareous till is composed of a silty to sandy carbonate rich matrix with numerous pebbles and the occasional cobble of Palaeozoic lime material.

1.1.4 Milling Methods

Mill capacities vary within the Hemlo camp on a tonnes per day basis as follows: David Bell 1,500, Golden Giant 3,000 and Williams 6,000 tonnes per day. All three operations use the carbon-in-pulp (CIP) gold recovery process. There are slight variations in the milling process, however the basic process consists of grinding circuits using semi-autogenous grinding (SAG) mills and ball mills or a combination thereof. Grinding is followed by thickening, pre-aeration and leaching, CIP recovery of gold, carbon stripping, electrowinning, retorting and melting into dore bullion. Tailings are pumped to a collection pond where the solids settle out and the water is pumped back to the mills as reclaim water.

Table 1.1: Williams Operating Corporation, ore mineralogy

Mineralogy	Mineral Chemistry	% Weight Range	% Average
Quartz	SiO_2	30.0 - 45.0	54.00
Microcline	$KAlSi_3O_8$	15.0 - 60.0	28.00
Muscovite	$Al(AlSi_3O_{10})(OH)_2$	3.0 - 35.0	9.50
Barite	$BaSO_4$	1.0 - 40.0	3.50
Pyrite	FeS_2	3.0 - 20.0	4.50
Molybdenite	MoS_2	0.1 - 0.5	0.16
Stibnite	Sb_2S_3	0.0 - 0.5	0.04
Realgar	AsS	0.0 - 0.2	0.02
Sphalerite	ZnS	0.0 - 0.2	0.02
Cinnabar	HgS	0.0 - 0.1	0.01
Tourmaline	$Na(Mg, Fe)_3 Al_6 (BO_3)_3(Si_6O_{18})(OH)$	0.2 - 0.5	0.25
Gold	Au	2.8-15.0 g/t	6 g/t
			100.00

Model Percentages after Kuhn, 1988; Complete mineralogy see Harris, 1989

1.1.5 Effluent Treatment

Design capacities of the effluent treatment plants (ETP) on a cubic meter per hour rate vary. David Bell treats 178 cubic meters per hour, Golden Giant treats 300 cubic meters per hour and Williams treats 583 cubic meters per hour. All sites rely on the natural degradation which occurs in the tailing ponds to reduce cyanide, suspended solids and metals prior to the pond water being treated. Golden Giant mine treats carbon column effluent using the Hemlo Process. Copper and irons salts form cyanide and hydroxide precipitates which are removed in a clarification stage. The Hemlo process is effective in control of suspended solids, pH, heavy metals, cyanide, arsenic and antimony. David Bell and Williams mine use similar effluent treatment processes.

In 1992, the David Bell tailings basin and the Williams tailing basin were combined under one management plan. David Bell commenced discharging their tailings into the Williams side of the basin, year round. During the warm weather months polished water from the Williams basin is pumped over to the David Bell side. This water is used as reclaim water for the David Bell mill and feed for their ETP. This management strategy has enabled David Bell to operate their ETP year round without having to treat for cyanide.

1.1.6 Compliance

Since discharging effluent in 1987, Williams mine has met the Metal Mining Liquid Effluent Guidelines for metal, with the exception of an elevated copper concentration of 1.0 mg/l back in 1990. All mines experienced difficulty in meeting the ammonia guideline of 10 ppm. When the Williams Mine and David Bell Mine tailings basins were combined under a single operating plan and Certificate of Approval #4-0075-92-006 the ammonia limit was set at 20 ppm. In September 1992 Williams Mine experienced an exceedance in their ammonia limit. The average four consecutive samples resulted in an ammonia concentration of 20.32 mg/l. At no time since the above incident has Williams been in contravention of the limits with the certificate of approval. Copies of Certificates of Approval are provided in Appendix 1. Effluent quality data, as well as some water quality data, are provided in Appendix 2.

David Bell mine has been in compliance with all requirements within their Certificate of Approval, except for a bioassay taken in August 1994. The bioassay resulted in a 96 hour LC_{50} for trout of 70.7%. The follow up bioassay a week later proved non-lethal.

Golden Giant Mine has been in compliance with their Certificate of Approval #4-072-83-846 since it was issued in 1984. the site is presently re-negotiating the certificate with confirmation expected the third quarter of 1995.

1.1.7 Seepage

Seepage around the combined Williams/David Bell tailings basin is required to be monitored monthly. In the event that copper is present at greater than 0.25 mg/l at designated sample sights the seepage must be collected and returned to the tailings basin. The source of the contaminated seepage must be investigated and measures taken to abate the seepage. The Golden Giant mine returns all seepage entering the ground water collection area to the tailings basin.

1.1.8 Acid Mine Drainage

A level deposition of tailings and flooding of the basin at closure is currently being planned to address the acid producing potential of the combined William and David Bell tailings basin. Golden giant has a similar plan, of water cover for their tailings pond at closure and will introduce aquatic plants.

Acid rock drainage potentials for waste rock stockpiles are presently being investigated by Williams and david Bell. Golden Giant has no waste stockpiles on surface, however their is a spoil pile consisting of overburden and oversize material from the quarry located on site.

Site drainage from the Hemlo Camp mines reports to Cedar Creek or Cigar Lake and eventually to the Black River Watershed. This watershed has been excluded from the Case Study Report since the treated effluents do not impact on or report to the Black River Watershed.

1.1.9 Comparison of Effluent Quality to the MMLER

Over the years of operation the Hemlo mines on occasion have exceeded the Metal Mining Liquid Effluent Regulation (MMLER) with regards to copper. Ongoing process changes have improved effluent quality as the downwards trends are apparent in the data listed in Appendix 2. The effluent treatment plant at Golden Giant Mine was originally designed for year round operation. With colder temperatures affecting the chemical reactions within the plant, the plant is now operated on a season basis, similar to Williams Mine.

Ontario's recent addition of Regulation 560/94, Effluent Monitoring and Effluent Limits for the Metal Mining Sector, to the Environmental Protection Act has increased regulatory requirements. Site specific concerns with contaminants not covered under Regulation 560/94 are being addressed in Certificate of Approvals for the site.

1.1.10 Physical Disturbance

Upon closure all structures will be removed from the properties with the possible exception of the Williams head frame. It is proposed that this structure be used as a radio and telecommunication tower. All waste rock slopes will be contoured to a 2:1 slope with the open pits allowed to fill up with run off water. The upper rim of the Williams' pits will be elevated above the flood line therefore, the top bench of the pits will be sloped to 2:1. The perimeter will be barricaded using boulders and warning signs posted for public safety.

1.2 Description of Quality and Quantity of Information

Baseline data was collected for Frank Lake during December 1984 (Environmental Baseline Studies, Frank Lake Watershed and its Confluence with the White River, Senes Consultants - December 1984). Baseline studies for Lim Lake include the following reports, A Report on the Baseline Fish Study at Herrick-Spangle Lakes, Sept-Oct 1984, ESP Consultants, August 1985, Preproduction Water Quality Monitoring Program conducted by Teck-Corona Operation Corporation, May 1984 - April 1985 - Internal Report, July 1985, Baseline Biological Survey for Noranda Inc. Hemlo Project, September 1983; Molson Lake - White River System, NTC Technical Memorandum 174 - June 1984.

In 1992 the Ministry of the Environment published the document, Water Quality in the Hemlo, Ontario Gold Mining Region, which precipitated the Companies to undertake a detailed environmental assessment of water quality, benthos, and fish communities in the Hayward Lake -Frank Lake drainage basin. The purpose of the study was to compare current conditions with pre-operational conditions, therefore benthic invertebrate sampling sites, fish surveys and water chemistry sampling sites were collected in the same locations as for the pre-operational data.

The references used for determining the adequacy of the metal mine effluent regulations consist of pre-operational data, as described above and a reference lake (Spangle Lake) located within the Hemlo region. Spangle Lake is a long narrow lake (approximately 3 km long and less than 0.5 km wide) located northeast of Herrick Lake. It provides significant flow into Molson Creek and subsequently, Herrick Lake. It does not receive any mine effluent and was sampled in 1992 for reference purposes. Spangle Lake is considerably larger than Lee or Lim Lakes and therefore has greater diversity of natural habitats. But it is similar in size to Herrick and Hayward Lakes and provides a good reference site for these lakes. Spangle Lake was also sampled in 1984 as part of the pre-operational environmental study(Harkness and Morgan, 1985).

Limited statistical analysis is presented in the ESP documents. Some statistical indices for benthos monitoring are provided in the baseline studies. In general, the data analysis is not conclusive enough for an exact determination of environmental effect.

1.2.1 Water Quality

Water quality data for both effluent and receiving water quality characterization has been completed monthly since the mines began operation. This data is adequate for assessing water chemistry changes in the receiver.

Field quality control was documented in the final Lim Lake Report under methods for sampling.

Laboratory quality control and quality assurance programs were documented extensively in the consultant's proposal submission and carried out during the analyses. However, the actual results of the QA/QC were not reported in the final documents. The analytical procedures for water samples used by the contract laboratory are listed in Table 3 of the Lim and Frank lake reports.

Data analysis with reference to the Aquatic Environmental Assessment of Frank Lake, Frank Creek and the White River consisted of comparison of present conditions with pre-operational conditions, the reference lake and the Provincial Water Quality Objectives or Canadian Water Quality Guidelines where applicable (Table 4 pg. 12). Routine water quality monitoring data from 1987-1992 was included to illustrate temporal trends from the early stages of operation to present.

1.2.2 Sediment Quality

For the Lim, Lee, Herrick and Hayward System sediment quality comparisons were made between pre-operational data, existing data, the reference lake and Provincial Sediment Quality Guidelines.

One of the problems noted with the sediment collection was the use of ekman grabs rather than cores. Given the typically low sedimentation rates experienced with Precambrian Shield lakes, and the relatively short time-frame that the mines have operated, only the uppermost portions of the sediment profiles would indicate the most recent deposits (and impacts) to the lake's bottom. The sectioning of sediment cores would have provided a more accurate delineation of what contaminative effects the mines actually may have had to the lake's sediment.

The iron concentrations in the sediments collected in Lim Lake were also questioned. There are substantial iron loadings to this lake from both effluent streams. However, iron concentrations leaving Lim Lake are below historic background water quality levels. This suggests that the iron should be precipitating in the lake. But the present study indicates that present day Lim Lake sediment iron levels have also decreased from background.

Sediments in the Frank Lake, Frank Creek and the White River and the Cedar Creek, Black River Systems were also compared with pre-operational data, reference sites and Provincial Sediment Quality Guidelines.

1.2.3 Benthic Macroinvertebrates

In the reports, benthic invertebrate samples collected at stations located near the inlet and outlet of the lakes and in the creeks were sampled in triplicate. One sample per site was sent to an independent expert for identification. Data analysis for Benthos consisted of the number of organisms, number of taxa, relative densities and diversity indexes.

One problem noted with the experimental design in most of these studies was that benthic invertebrate sampling sites were located in less than ideal location for sensitive species. In lakes, the benthic samples were generally collected from the deep profundal sediments where conditions are unsuitable for sensitive organisms. Samples from the lake littoral zones were pooled with samples from the profundal zones giving a general lake-wide total of organisms, adding to interpretation problems.

1.2.4 Fisheries

Fishery pre-operational and operational data were based on catch per unit effort sampling programs. In these reports the number of nets and traps is identified for each lake. However, in the Senes report produced in 1984, there was no net set time given.

The field sampling methods were not outlined clearly for the mercury sampling conducted by Ecological Services for Planning in 1993.

The current fishery data was compared with pre-operational data but was limited to the number and species of fish caught. CPUE was used to compare the current fishery in the receiving waters with the reference lake as well as numbers and species of fish caught.

These results are qualitative and reflect the presence/absence of fish in a given waterbody. They can be greatly affected by life history patterns, habitat type or season of the year.

The netting effort was also for the collection of samples for fish flesh contaminant analysis. To ensure that samples were taken of the "local" populations, the netting was done in the fall when the expected primary species were not exhibiting any spawning migration behaviour.

1.3 Aquatic Effects Assessment

1.3.1 Water Quality

Both the Golden Giant and David Bell mines discharge their treated effluent into Lim Lake. During the early years of operation contaminant levels in Lim Lake were high. Ammonia, mercury and antimony concentration at Lim Lake's outflow (1.2 km downstream of final effluent discharge location) had on occasion exceeded the Ontario Mining Effluent Guidelines for final effluent. Ammonia, free cyanide, copper and nickel levels had also exceeded PWQO's as far as 2.3 km downstream of Lim Lake.

Since mid to late 1987, there has been significant decreases in Lim Lake's total cyanide and metal levels (particularly antimony and molybdenum). These metal reductions were achieved through effluent process changes implemented in early 1988. Cyanide decreases reflect a number of process changes which included a major reduction in the use of cyanide during gold recovery process, and the increased natural cyanide destruction within the tailings basin, due to a larger surface area.

Changes to water quality in the Hayward Creek watershed have been minimal, although there have been detectable increases above background levels for several metals (including antimony, molybdenum and mercury) and cyanide. There has been little or no change to the concentration in the White River.

There has been an increasing trend within the natural environment downstream of the mines' effluent discharge point such that total ammonia levels are seasonally approaching 20 mg/l at the Lim Lake discharge.

In the Frank Creek watershed antimony, copper, molybdenum, nickel, free cyanide and ammonia levels periodically exceed Provincial Water Quality Objectives at the Frank Creek discharge sampling point. Ammonia also regularly exceeds 10 mg/l at the Frank Lake discharge point (ie. after total lake mixing/dilution).

1.3.2 Sediment Quality

Antimony, copper, manganese, molybdenum, nickel, tin and zinc levels in the sediments of Lim Lake were higher than pre-operational levels or levels in the reference lake. Concentrations of copper, manganese and nickel exceeded the Severe Effect Level according to the Ontario Provincial Sediment Quality Guidelines while chromium, lead and zinc exceeded the Low Effect Level.

Sediment concentrations in Frank Lake are either lower or have not changed from background levels since mining operations began and in most cases are comparable to the reference lake. The sediment composition is a reflection of the local geology.

1.3.3 Benthic Macroinvertebrates

Benthos sampling was completed at both Lim Lake and Frank Lake during baseline data collection in 1983 and 1984, and as part of the operational survey conducted during 1992. Samples were collected in both Lim Lake and Frank Lake as well as the downstream creeks. Data analysis for 1983/1984 and 1992 were completed in the same fashion. Taxonomic groups of organisms were sorted in terms of sensitive, intermediate and tolerant organisms. The following taxonomic groups are general indicators of long-term water and sediment quality:

Ephemeroptera:	sensitive
Trichoptera:	intermediate
Chironomidae:	tolerant

Table 9 of Report No. 257 provides a comparison of benthos invertebrates between the lakes and the watershed between September 1983 and September 1992. Benthos samples collected from Lim and Lee Lakes contain low numbers of taxa during the pre-operational periods. Benthic fauna of the downstream lakes, Herrick and Hayward, and the reference lake, Spangle Lake, were more diverse; both in greater numbers of taxa and density of organisms. Indices also indicate the presence of greater diversity of organisms. Report No. 257 also summarizes that Herrick and Hayward Lake are similar to that of Spangle Lake suggesting that they are of similar habitat quality in profundal regions.

The low number of taxa and low densities of organism in these lakes is typical of the benthic communities found in the profundal zone of lakes. Lotic habitats sampled downstream at Molson Creek (MC1, MC2 and MC3) and Herrick Creek were similar in total number of taxa when comparing 1983/84 and 1992, except for the furthest upstream station in Molson Creek (MC1) where fewer taxa and lower density was found.

The pollution sensitive Ephemeroptera were present in Spangle, Herrick and Hayward Lake, but not in Lim or Lee Lakes during both study periods.

Trichoptera were present in Spangle and Hayward Lakes but not in Herrick Lake. In lakes, the benthic samples were collected in the deeper profundal sediments where conditions are often unsuitable for sensitive benthic organisms such as Ephemeroptera and Trichoptera. Therefore their absence from these habitats is not unexpected. The profundal benthic communities of Lee Lake and Lim Lake are characterized by low numbers of organisms dominated by Chironimidae but are similar to the community structure observed in Lim Lake during the pre-operational study (Wood, 1984).

As with Lim Lake, Frank Lake samples were also collected from the deep profundal sediments where conditions are unsuitable for sensitive benthic organisms. In 1992 the community structure of Frank Lake was similar to that observed during the pre-operational sampling. During pre-operational studies the dominant taxa were Diptra and Oligochaetes, with organism abundance ranging from 7 to 35% per sample (Senes, 1984). Diptra accounted for 94% of the organisms present during the pre-operational survey with only 5 taxa found. Six different taxa were identified in fewer samples during the 1992 survey. From this information it was determined by the consultant that there "has been no discernable impact from mining operations on the benthic community of Frank Lake" (E.S.P., 1993).

Changes within the benthic community structure downstream of Frank lake were attributable to high water conditions and the fact that pre-operational study samples were taken successfully only in areas with heavy deposits of woody debris and fibre. In 1992, samples were taken from areas with some woody chips but significant amounts of sand. The findings emphasize the importance of recognizing natural variability in the absence of external impacts.

In summary, pre-operational and operational benthos sampling indicates little change. However, it should be emphasized that the sampling locations are limited basically to Chironomid-dominated habitats. Community structures for both 1983/84 studies and 1992 studies are similar. No pollution sensitive species were found during either study.

A major change in the number of taxa and organisms occurred immediately downstream of Lim Lake in Molson Creek. It is difficult to determine (based on two surveys) whether the decrease in taxa and organism density is attributable to effluent discharges.

There were no observable changes in the Frank lake system.

1.3.4 Fisheries

Pre-operational studies in Hemlo area lakes showed that they generally supported either northern pike/white sucker or walleye/northern pike/whitefish/white sucker communities. Netting indicated that the Pic, Black and White Rivers contained resident walleye, northern pike and whitefish. Muskellunge were caught in the lower reaches of the Black and Pic Rivers. The lower portions of these rivers or their tributaries also are spawning areas for migrating salmonids from Lake Superior.

Mercury levels of fish sampled from the Hemlo area prior to mine development, were high. As noted by Laine, 1992, approximately 50% of the walleye and the majority of northern pike sampled exceeded the 0.5 mg/kg guideline for unlimited consumption. There were some local variations in fish mercury concentrations with the highest levels found in the headwater areas of the Hayward Creek watershed (i.e. Molson, Lim, Spangle and Herrick Lakes). Since there were no industrial point sources of mercury in this watershed, the high mercury levels are thought to be the result of ambient environmental conditions and /or atmospheric transport. Levels of all other metals examined (arsenic, antimony, zinc and lead) were low, with the values below or just above detection levels.

The ESP, 1993 study on the Frank Lake, Frank Creek and the White River determined that concentrations of mercury in the fish catches were similar to pre-operational conditions.

The fish catch data for Frank Lake showed that only one species of fish was caught in 1992 while in 1984 three species of fish were captured. The CPUE could not be compared as information regarding the net sets for 1984 was unavailable.

The results of the ESP, 1993 study for the Lim Lake, Lee Lake, Herrick Lake and the Hayward Lake system were inconclusive. Although, the numbers of fish caught during the pre-operational survey in Lim Lake were low, the most common fish species caught, northern pike, was not captured in the 1993 survey despite an increased fishing effort. Since the mines have been in operation, the fish community appears to have changed in Lim Lake.

The ESP 1993 study on the Cedar Creek/Black River System showed that fish numbers and diversity in Cedar Creek and the Black River were higher in the 1993 survey than in the pre-operational survey.

1.4 Conclusions

The summary of all previous studies to date provided in the Lim Lake, Lee Lake, Herrick Lake, Hayward Lake System Report demonstrates that although there are measurable impacts downstream, the primary impacts on biota have been limited to Lim Lake. Furthermore, the Lee Lake study shows the system's ability to withstand present loadings and to provide the necessary focal point for re-colonization once suitable conditions exist again in Lim Lake. However, by not reporting site-specific, replicate sample results for each lake, it cannot be determined if there may have been any actual differences in species composition/abundance by depth or if there were any area-specific differences related to the proximity of the effluent discharge point. Data are insufficient to determine the effect of the mine discharge on the benthic organisms.

The information available for Frank Lake, Frank Creek and the White River provides a synopsis of water quality conditions and describes the decreasing trend with respect to final effluent contaminative effects on the watershed's water quality. This is a reflection of reduced environmental loadings through improvements in effluent quality. Overall, conditions in water quality (receiving environment) have improved over time.

These studies also provide an assessment of the benthic and fish community structure in the Frank Creek Watershed. The results indicate that the impact on Frank Lake benthic communities appeared to be minimal. The fish survey data were insufficient to determine whether receiving environment effects on fish, fish habitat or fisheries resources have or have not occurred.

The selective use of presence/absence data based on minimal collection efforts during pre-operational data collection has made interpretation of the data difficult. This emphasizes the need for more detailed spatial/temporal surveys for all forms of biota, particularly within the immediate receiving water bodies.

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2 Red Lake Gold Camp

2.1 Site Description

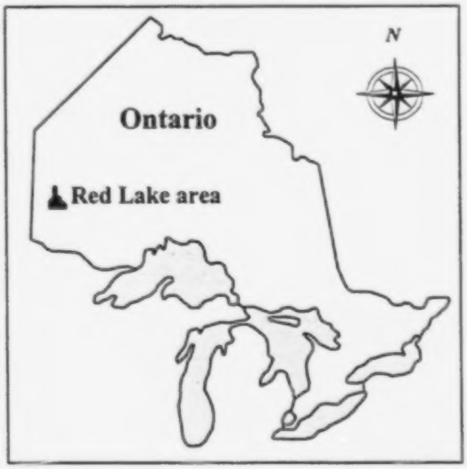
2.1.1 General Mine Site Description

The mines of the Red Lake area are approximately 140 km north of Kenora by air and about 80 km east of the Manitoba border (Figure 2.1). The terrain is typical of the Precambrian Shield with low-lying areas, wetlands and rolling hills. The ground cove contains a thick coating of glacial clay, sand and boulders.

Gold mining activity has been undertaken in the area since the 1930's. The currently active mines are the Placer Dome (Campbell Mine) operation and the Goldcorp (Red Lake Mine, formerly Dickenson). Balmertown is the closest settlement to the mines (Figure 2.2).

Balmer Lake (tertiary pond) receives tailings discharge from both mines and discharges to Balmer Creek over an adjustable weir. Both Red Lake and the lower portion of Balmer Creek discharge into the Chukuni River and eventually into the English River, which joins the Winnipeg River at the Ontario-Manitoba border.

Figure 2.1: Location of Red Lake area



Most of Balmer Lake sediments are overlain by tailings released prior to the construction of the tailings containment area in the late 1970's. Similarly, Balmer Creek sediments have also been overlain by tailings material.

Abandoned mine tailings areas which have been covered and revegetated also exist in different areas along Balmer Creek downstream of the lake. When there is no discharge from the lake, 14% of the flow of the creek originates from the Balmertown Water Pollution Control Plant (WPCP). The WPCP has primary and secondary (extended aeration) treatment and is chlorinated.

2.1.2 History

There are two mines located within the Red Lake Gold Camp. The Red Lake Mine (formerly Dickenson Mine, now owned by Goldcorp) and the Campbell Mine.

The history of the Red Lake Mine dates from 1926 when the property was first staked during the Red Lake Gold Rush. It was in 1944 that Brewis and White Limited financed new exploration and drilling. Dickenson Red Lake Mines Limited was incorporated and diamond drilling started in March 1945.

Shaft sinking was started on July 10, 1946. Production mining commenced in 1948 at a rate of 125 tons per day. Modification and expansion of the mill saw the capacity rise to 500 tons per day by 1959.

Today the present rated mill capacity is 900 tons per day.

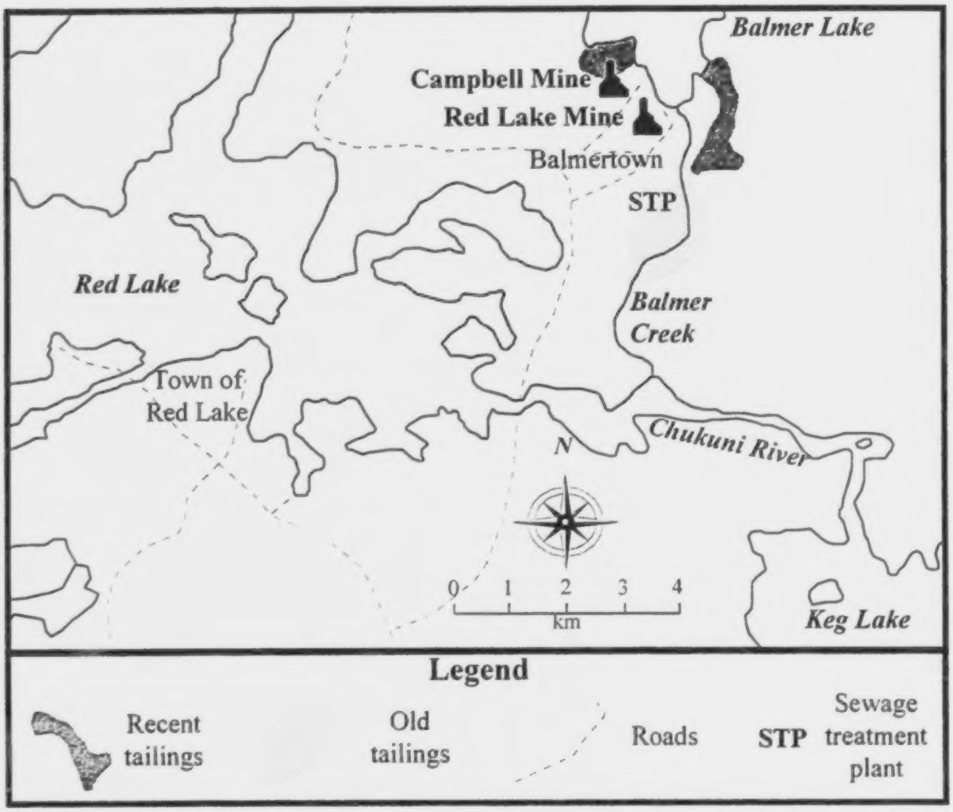
The Campbell Mine property was staked by George Campbell in the 1940's. Dome Mines optioned the property and completed initial exploration drilling which discovered the "A" zone.

The mine's history began with the sinking of a shaft to an initial depth of 597 feet in 1947. Mill construction was completed by June of 1949 and the first gold bar was poured in July. Since that time the shaft has been extended to 4217 feet and production is currently at 1600 short tons per day.

2.1.3 Geology

The property is located within the Red Lake Greenstone Belt, and Archean Supracrustal Volcanic Sedimentary complex with a large number of significant gold deposits. Regionally,

Figure 2.2: Red Lake area mines and surface drainage


Balmer Lake
Campbell Mine
Red Lake Mine
Balmertown
STP
Red Lake
Balmer Creek
Town of Red Lake
Chukuni River
N
0 1 2 3 4
km
Keg Lake
Legend
Recent tailings
Old tailings
Roads
STP Sewage treatment plant

this supracrustal complex has been divided into three main sequences; the lower, middle and upper sequence.

Strong penetrative cleavage is present throughout the Red Lake greenstone belt. The regional metamorphic grade is generally greenschist facies but within 1.5 to 3. kilometres of the major intrusive, the grade increases to amphibolite facies. Higher carbonate and silica alteration appears to accompany the higher metamorphic grade.

The Red Lake Mine lies within the Cochenour-Gulloch Lake Deformation zone, just east of the Campbell Red Lake Mine. It is situated on the hanging wall side of a southeast plunging anticline, in a sequence of metamorphosed Precambrian volcanic,sedimentary and plutonic rocks.

The dominant rock type in the mine consists of a thick series of tholeiitic to komatiitic rock of originally basalt to andesite compositions.

The characteristics and mineralogy of the three basic ore types are as follows:

1) Fracture filled veins which are one to five feet wide consisting of colliform quartz-carbonate containing pyrite, pyrrhotite, arsenopyrite, minor sphalerite, and visible gold.
2) Replacement veins, which are four to fifty feet wide veins consisting of blue quartz-carbonate with 60% arsenopyrite crystals, heavy bands of pyrite pyrrhotite, minor sphalerite and fuchsite with visible gold.
3) Pod or pipe-like silicifiied zones consisting of sheeted quartz-carbonate veinlets overprinted by quartz (silification) containing pyrite, pyrrhotite, sphalerite,stibnite, arsenopyrite, fuchsite, and visible gold.

2.1.4 Mining Methods

Both companies use conventional underground methods. The Red Lake Mine workings are serviced by two vertical shafts. Total depth of the mine is 5,700 feet and levels are spaced at 38 meter intervals between the surface and the 4th level. Below that they are at 46 meter intervals.

The mine employs a combination of tight and open mechanized cut and fill and long hole mining methods. Depending on the size and structure of the individual ore zones, the ore is mucked with the use of diesel and electric scooptrams, cavos or slushers.

2.1.5 Milling Methods

2.1.5.1 Red Lake Mine

At one time the gold was extracted using amalgamation. However, the Red Lake Mine roaster was shut down in 1980.

The Red Lake Mine mill uses the Merril Crow process to recover gold contained in the ore. The ore is crushed to allow cyanide salts to reach and dissolve most of the gold and silver. This solution is then separated from the solid particles and gold precipitates by the injection of zinc powder. The zinc gold silver compound is then filtered and periodically refined to produce the “dore bullion”.

The solid particles stripped of their gold content are then disposed of in slurry form to the tailings ponds.

A portion of the gold in the ore body is associated with sulphide particles which must be processed through a sulphide flotation circuit. A sulphidizer is added to the slurry in the form of sodium sulphide. The slurry is then pumped to two smaller conditioning tanks where copper sulphate is added. Copper sulphate is necessary to overcome the affect of an residual cyanide in the slurry and to act as a resurfacing agent to allow the collector to actively coat the sulphide particle. The collector used is sodium isopropyl xanthate. The xanthate is added to the overflow pumpboxes of the two conditioners used for copper sulphate. Finally the frother, Dowforth 250 is added and this too goes into the overflow pumpboxes with the xanthate.

The slurry is pumped to the Prochem flotation cells and then to the Denver scavengers. The concentrate from these two systems is cleaned in a bank of four Denver cells and then reports to the concentrated storage boxes.

2.1.5.2 Campbell Mine

The ore at the Campbell Mine is crushed down to minus 0.625 inches in size before being sent to the rod mill-ball mill grinding circuit. The grinding circuit is closed by two stages of cyclones.

The grinding circuit is followed by gravity separation where jigs are used to recover free gold and sulphide concentrates. Column flotation is then used on the pulp to recover remaining sulphides as a concentrate.

The concentrate resulting from the flotation process is thickened to about 65% solids, contacted with weak acids them pumped into an autoclave for pressure oxidation. The oxidation process converts the sulphides to sulphates and the arsenic to ferric arsenate. The oxidized slurry is then discharged to a two stage countercurrent wash circuit and then neutralized prior to the oxide cyanidation circuit. Gold bearing solutions are recovered by filtration.

Flotation tailing is leached in cyanide for approximately 72 hours. Carbon is added to the leach and the gold in solution is absorbed onto carbon. Loaded carbon is screened from the pulp and using a caustic solution, the gold is stripped from the carbon. The carbon is then reactivated in a rotary kiln and recycled.

Solutions from the oxide leach and the carbon strip are combined then clarified and deaerated. Zinc is added to the clear solution causing the gold to precipitate. It is then collected in a plate and frame press.

The Campbell Mine also used amalgamation until the roaster was shut down in 1991. The Campbell Mine uses the sulphur dioxide/air process to reduce cyanide and ferric ion addition to remove arsenic. Metals are also precipitated at Placer Dome by the addition of calcium hydroxide.

Mill capacities vary within the Red Lake camp. The Red Lake mine is approaching on average 1,000 tons per day whereas the Campbell Red Lake 1,600 short tons per day.

2.1.6 Effluent Treatment

Balmer Lake is a small inland lake located approximately 150 km northeast of Kenora, Ontario and six kilometres east of Red Lake with a normal lake surface area of 259 hectares and a drainage basin of 32.9 square kilometres. The average depth of the lake at normal lake elevations is approximately 3.0 meters and has a maximum depth of 3.5 meters. Surface runoff from the basin drains into Balmer Lake by four creeks and exits the lake downstream via Balmer Creek. Travelling southward along Balmer Creek, runoff from the basin flows into the Chukuni River which drains Red Lake.

Historically, Balmer Lake has been utilized as both a source of fresh water for gold mining processes as well as a final treatment facility for the effluent from several tailing ponds located along the shoreline. Red Lake Mine is located along the eastern shoreline of Balmer lake and pumps water from the lake at a rate of 0.03 m^3/sec. Fresh water for mining process operations is also supplemented from the local municipal water distribution system. The process waters are ultimately released into Balmer Lake at a rate of 0.04 m^3/sec.

Campbell Mine is located along the western shoreline and pumps lake water at a rate of 0.04 m^3/sec. Similarly, municipal water is also required for process operations and the total release back to the lake is estimated at a rate of 0.05 m^3/sec.

In the past few years a ditch has been constructed along the western edge of the Campbell tailings area. This ditch is to direct all runoff water from the higher ground away from the tailings area and directly into Balmer Lake. The ditch captures a catchment area of 400 ha.

Both mines maintain separate internal primary tailings management systems. The Campbell Mine facility has a drainage area of 3.9 square kilometres that contributes runoff water only through the release from the tailings ponds.

The Red Lake Mine has a 5.0 square kilometre drainage area that drains through the facility and releases to the lake through the tailings ponds.

Balmer lake provides for natural degradation of cyanide as well as storage during periods when the quality of water in the pond does not meet effluent limit requirements as stipulated in the Certificate of Approval issued by the Ontario Ministry of the Environment and Energy. A weir located at the outlet of the lake is used to control discharge into Balmer Creek. A copy of the Certificate of Approval is provided in Appendix 3.

In 1991, the general operating practice for the lake was to discharge continuously to Balmer Creek until effluent quality approached a condition of non-compliance with the Certificate of Approval requirements. This happened regularly in spring at the time of ice break-up, although it could also occur at other times of the year. At ice break-up, total cyanide levels generally rose above the effluent limit of 2 ppm stipulated in the C of A. The weir was then closed and water retained until cyanide levels fell below 2 ppm.

Since 1991, construction of a 1.8 X 10^6 m^3 polishing pond and the raising of existing dams has allowed Campbell to store all mill process effluent from November to May before releasing to Balmer Lake. After treatment the effluent if released to Balmer Lake. Balmer Lake is discharged from July until January until low water levels and ice build-up halt discharge for another season.

Effluent quality data are provided in Appendix 4

2.1.7 Compliance

In 1990 Red Lake Mine and Campbell Mine had eleven exceedances for arsenic and 2 for suspended solids at the weir in Balmer Lake. Following this the Ontario Ministry of the Environment and Energy issued a new C of A stating that "No discharge from the Tertiary Clear Water Pond will be permitted from 01 May to 01 July of any year without written approval from the District Office or his or her representative." Hydrologic studies by MacLaren Plansearch (1991) showed that there is frequently inadequate capacity in Balmer Lake (the tertiary clear water pond) for storage of runoff during the spring melt period. There is a 20 to 25% chance that the Tertiary Pond will exceed its capacity Between May 1 and July 1st requiring an emergency discharge.

Several samples collected by Beak in 1991 at the outfall of the Tertiary Pond showed arsenic and cumulative metal levels in excess of the C of A limits between April and August, 1991. All other chemicals were within the C of A limits for the duration of the sampling period.

Effluent quality data collected between 1986 and 1991 by MOE showed Zn, Pb, CN and ammonia levels were consistently within the limits specified in the C of A. However, TSS, Cu and Ni limits were occasionally exceeded. The C of A limit for Cu was only exceeded between the months of March and June. Cumulative metal levels exceeded the C of A limits approximately 50% of the time (particularly during the spring months), whereas arsenic concentrations were consistently over the limit.There has been little change in the outfall quality since 1971 with the exception of Pb which decreased dramatically in 1974. Although several figures give an impression of an increase in mean concentration or a tendency toward greater variability this is probably due to improved analytical procedures.

Effluent data for 1991 to 1994 shows continued improvement in quality at the weir discharge with 100% compliance with being reached with C of A limits in 1994.

As of June 1993, Campbell Mine's control point for their C of A has been changed to L1(#3 decant) from the Balmer Lake weir (L2). However, ammonia and toxicity are regulated at L2 still.

In 1994, Red Lake Mine was in 100% compliance at all Certificate of Approval control points (D. Mchaina, personal communication).

2.1.8 Effluent Characterization

2.1.8.1 Tertiary Pond

A study conducted from 1971-1975 (Pollutech, 1976) found that considerable quantities of arsenic, cyanide and heavy metals were being discharged to what is now known as the Tertiary Clear Water Pond (formerly Balmer Lake) from Campbell Mine. Contaminant levels were reduced through the use of the Tertiary Pond. Although Cu and Ni levels in the outfall of the pond periodically exceeded the Ontario Effluent Guidelines (MOE, 1973) of 1.0 mg/l each, As and CN were consistently within their respective guideline limits of 1.0 mg/l each. A study conducted by MOE in 1978 found that although Fe concentration exceeded Provincial Water Quality Objectives (PWQO) of 0.3 mg/l they were considered typical for Northern Ontario waters (MOE, 1982).

In 1986, a study by EAG (EAG, 1986) established seasonal water quality trends within the Tertiary Pond. Results indicated cumulative metals (Pb,Cu, Zn, Ni) and CN within the pond were consistently below the Ontario Ministry Mineral Industry Effluent Guidelines (MIE) of 1.0 mg/l and 2.0 mg/l respectively except during the month of May when both levels were exceeded. Arsenic was close to the MOE Guideline limit of 0.5 mg/l through out the year except in August when it ranges from 0.6 to 0.65. It was later found that these levels of As may have been underestimated by 10 to 50% due to the test method used at that time (Beak, 1991).

The 1986 report concluded that the tertiary pond was an effective polishing area for reduction of CN and heavy metals but offered little treatment for As other than dilution.

2.1.9 Other Site Information

There are several other inputs to the Balmer Creek system downstream of the Tertiary Pond. Located approximately 350 m downstream of the weir is the Balmertown WPCP. The discharge from this plant is the only notable source of dilution for the Tertiary Pond outflow during discharge conditions. This dilution is small relative to the discharge from the weir.

There is also a municipal dump located near Balmer Creek approximately 1300 m upstream from the Chukuni River and abandoned tailings near the creek downstream of the weir. Timber harvesting activities in the area may cause increased levels of total suspended solids.

Water quality data have indicated that the abandoned tailings along the creek and/or the Balmertown WPCP contributed significantly greater concentrations of arsenic, aluminum, iron, chromium and lead to the creek relative to the concentrations that would have been discharged from the weir, had it been operational at this time (MOE, 1993). The data from this study also indicated that there was a source of antimony to the lower creek independent of input from the weir.

2.2 Description of Quality and Quantity of Information

2.2.1 Water Quality

The water quality data is extensive and of good quality. It would appear from the data that there has been an increase in mean concentration during more recent years for (Cu, NH_3-N, Ni, and cumulative metals. However this is likely due to improved accuracy and precision in analytical techniques.

2.2.2 Benthic Macroinvertebrates

Benthic surveys were conducted on Balmer Creek in 1973, 1978, 1989 and 1991. Direct comparison between these surveys is not possible due to differences in the number of samples collected at each station, the area of bottom sampled per grab, the mesh size through which the organisms were sieved and the sorting techniques used.

The pattern of benthic communities in Balmer Creek is similar in all the historical surveys

2.2.3 Fishery Data

Fishery surveys were conducted for fish habitat, tissue contamination and toxicity. Surveys conducted in 1986, 1988 and 1991 established fish habitat conditions and resident species.

In 1975 and 1982 studies were conducted on the tissue contamination of fish species. The 1975 report made no statistical comparisons and only general observations were made from the raw data.

The 1982 report included a good description of the methods and tools used for the survey and the type of tissue used (epaxial muscle) for analysis.

Fish toxicity surveys were conducted in 1982, 1992 and 1994. The 1992 report was weak in that there was a lack of consistency in the number of sites used per experiment, minnow stocks used were variable and not all water chemistry results were available at report writing. Water chemistry samples were not taken at all sites.

Overall the data collected for these sites is adequate. In most cases where a report was weak in an area the follow-up reports compensated for the missing information. There is information covering water quality, sediments, benthics and fisheries.

Generally, upstream samples were used as the reference and were taken at the same time as the downstream samples.

In some of the older report the sampling and study methods may not have been fully described. However, more recent studies that have outlined methods have shown that conclusions drawn from the historical reports are consistent with results from more recent work.

2.3 Aquatic Effects Assessment

2.3.1 Balmer Creek

The Tertiary Pond provides the majority of the flow into Balmer Creek on an annual basis. Due to this input there was a considerable difference observed in chemical concentrations in Balmer Creek above the inflow to the Tertiary Pond compared to concentrations in Balmer Creek downstream of the pond. Of the thirty-three parameters analyzed for over half were higher downstream of the Tertiary Pond as compared to upstream (samples taken the same day). Levels of Fe, Mn and V were higher upstream of the pond than downstream.

The 1982 MOE study found that Balmer Creek downstream of the Tertiary Pond contained elevated levels of P, N, turbidity, conductivity, CN and several heavy metals relative to Balmer Creek upstream of the Tertiary Pond.

Downstream of the sewage discharge for the Balmertown Water Pollution Control Plant (WPCP) PWQO for the protection of aquatic life for As, Cu, Zn, Ni and Fe were exceeded. CN was found to be elevated as well but was found to exist mostly in a complexed form less toxic than free CN and therefore of little concern (MOE, 1982).

There is a slight improvement in water quality in Balmer Creek by the time it nears the Chukuni River. However, levels of most metals remain elevated relative to background (Balmer Creek upstream of the Tertiary Pond) and PWQO's for most C of A parameters tend to be exceeded.

Water quality data for the weir for 1992-1994 is presented in Appendix 4. These data indicate continued improvement in effluent quality due to abatement measure over the past few years. This improved effluent quality should be reflected by improved conditions in Balmer Creek.

2.3.2 Chukuni River

Pollutech (1976) sampled upstream and downstream of the confluence of the Chukuni River with Balmer Creek from May to October from 1971-1975. During this sampling period all parameters (except Fe) were below PWQO (MOE, 1973)Samples collected downstream of the Balmer Creek and Chukuni River confluence by the MOE in 1978 and 1979, showed all parameters were below PWQO except for Cu.

2.3.3 Benthic Macroinvertebrates

Benthic surveys conducted on Balmer Creek in 1973, 1978 and 1989 have indicated substantial impact on the benthic community. All of the samples collected from the creek showed reduced numbers of pollution-sensitive species and diversity of organisms collected relative to reference samples upstream of the Pond.Due to the differences in sampling methods direct comparisons of the studies cannot be made (Beak, 1991). However the three surveys generally indicated the same conditions in Balmer Creek. The benthic community in all studies was dominated by midge larvae. The sampling station closest to the Chukuni River showed slightly improved conditions where the community was dominated by tubificid oligochaetes. Tailings material was present at all sampling stations.

In 1989 (MOE, Unpublished data) a qualitative survey was done in the aquatic vegetation located downstream of the Balmertown WPCP. This study indicated a wider diversity of organisms than were collected from bottom sediments. This suggests that general water quality is good enough to support some sensitive organisms but sediment quality is not.

2.3.4 Fishery

Balmer Lake contained a viable walleye fishery from the late 1940's to the 1960's but the habitat quality degraded such that the lake is now more of a polishing pond for both mines. During the winter, spent cyanides accumulate under the ice on the lake and concentrations build to levels which are potentially lethal to aquatic life. A chemical and biological assessment of the pond and Balmer Creek was undertaken in the late 1970's by the MOEE (MOE, 1982). This study indicated that severe environmental stress, primarily caused by elevated concentration of arsenic, cyanide and a number of heavy metals, had resulted in conditions unsuitable to maintain a normal aquatic community in the pond. After four days of gillnetting there were no fish collected from the pond. Balmer Creek downstream of the weir is used by non-resident walleye, pike, perch and white suckers to spawn in late spring.

Pollutech 1975 conducted a survey on the bioaccumulation of arsenic in fish tissue from the Red Lake watershed and control lakes. Arsenic tissue concentrations in fish were generally higher in 1975 than in 1973. Fish captured from the control lakes had a lower arsenic concentration in their tissues than did fish captured from the Red Lake watershed. It was also found that within the Red Lake watershed arsenic concentrations in fish tissue increase with fish age.

In the spring of 1985 a fish kill occurred in Balmer Creek at ice-out when the discharge from the weir began to flow. The companies constructed a rock rubble dam in the creek at the township waste disposal site to limit fish access to the area below the weir. MOEE subsequently required that the companies hold back the overflow at the weir from May 1 to July 1 each year and that the rubble dam be removed. In 1992, total cyanide levels of the lake rose from 225 μg/L on May 10th to 4900 μg/L on April 24. The levels stayed above 1000 μg/L until sometime after May 19th. Requests for emergency discharges during this prohibited period, to maintain the integrity of structures, are a continuing concern. However, from 1993-1995 there have been no requests for emergency discharges.

MacLaren Plansearch (1991) undertook a preliminary reconnaissance and habitat assessment of Balmer Creek in 1990. The report noted that the creek is dominated by a marsh setting with dense emergent vegetation lining approximately 75% of the creek channel. The remaining 25% of the creek area is comprised of abandoned tailings areas. Bottom substrates in the Creek were almost exclusively soft sediments with only three areas of hard substrates (gravel) being located.

A comprehensive fisheries assessment program was initiated by BEAK in 1991. Toxicity results from this program showed that the Tertiary Pond (Balmer Lake) was lethal to Daphnia magna and caused periodic lethality to rainbow trout. It appeared that the toxicity was the result of elevated cyanide and/or copper levels. Other chemicals, including zinc, ammonia, arsenic and iron, were also identified as potential contributors to the effluent toxicity.

Sublethal effects to early life stages of fathead minnows were observed in the laboratory at low effluent concentrations, but the magnitude of effect was relatively minor and was not evident in the field study.

The water in Balmer Creek was found to be non-lethal to fathead minnows in a four-day in situ exposure during Tertiary Pond discharge conditions.

Field studies showed that the Balmer Creek fish community was dominated by warmwater species such as pike, walleye, yellow perch, white sucker and several cyprinid species. There are two distinct communities within the creek; the resident inhabitants and the migratory inhabitants which visit Balmer Creek seasonally.

The wide range of size and age classes of northern pike, walleye and white suckers found in Balmer Creek during this survey suggests that the population have not suffered from any serious toxic exposure causing reproductive failure.

Low numbers of young-of-the-year, low numbers of spent female walleye and lack of any observed walleye spawning activity suggest some degree of reproductive impairment in Balmer Creek. This may be due to an absence of any appreciable flow in the creek during spawning season.

Cyprinid tissue tested for this study showed that there is little to no accumulation of mercury or arsenic in these fish that could be attributed to the mining or milling activities.

The most obvious effect noted in the 1991 survey was the effect of zero discharge from ice break-up to mid-summer. Both white sucker and walleye are known to spawn on cobble substrates under relatively high water velocity conditions. The closure of the weir at ice break-up in April, just prior to spawning season prevents the occurrence of high water velocities in Balmer Creek.

The Aquatic Toxicology Section of the MOEE in collaboration with the Regional MOEE office has investigated the effect of water from the area in 1993 on fish eggs placed in incubation chambers at the site. No significant differences were observed comparing eggs placed at upstream, downstream and weir sites with respect to egg mortality but sac fry mortality was significantly greater at the downstream site compared to the other two sites. The abandoned tailings along Balmer Creek and/or the Balmertown WPCP effluent contributed significantly greater concentrations of arsenic, aluminum, iron, chromium and lead to the creek relative to the concentrations that would have been discharged from the weir, if it had been in operation during this study.

Water quality data summaries for 1992-1994 for the weir discharge show continued improvement with the mines achieving 100 % compliance with C of A parameters in 1994(Appendix 3).

In situ fish toxicity experiments (Mchaina, 1992, 1994) in 1992 and 1993 showed that fish mortality rates were insignificant at most stations except the weir station where one incident of 100% mortality was recorded.

2.4 Conclusions

Campbell and Red Lake mines have continued to improve site conditions to improve conditions within Balmer Lake. Campbell Mine has constructed a polishing pond that will store their effluent so that it can be treated and discharged to Balmer Lake. The control point for their Certificate of Approval has been moved back to this point for most C of A parameters. The construction of the polishing pond has reduced the risk of emergency discharge from Balmer Lake during the periods when the weir is closed.

The construction of a ditch to direct flow from the higher areas of land directly to Balmer Lake will increase the dilution capabilities of the lake by ensuring that surface water is not contaminated prior to entering the lake.

There are natural temporal variations in the water quality of Balmer Creek, upstream of the tertiary pond. In the past, parameter levels at the outfall of the Pond were elevated relative to upstream levels and Certificate of Approval limits for cumulative metals, arsenic, and to a lesser degree, copper were frequently exceeded at the outfall of the pond necessitating the zero discharge during the spring. However, since 1992 the quality of the effluent discharge from the weir has continued to improve and in 1994 the companies achieved 100% compliance with their Certificate of Approval.

Despite the limited dilution, there is improvement in the water quality of Balmer Creek by the time it nears the Chukuni River. Downstream of Balmer Creek in the Chukuni River PWQO's for ammonia, arsenic, lead and zinc are never exceeded. In the past, copper and nickel levels periodically exceed their respective PWQO's. However with improved effluent quality observed in 1994, these levels should decrease as well.

Monitoring data suggest that receiving environment effects on fish, fish habitat or fisheries resources has occurred. However, conditions in the receiving environment have been improving over time. The restricted benthic community present in 1991 in Balmer Creek downstream of the outfall from the Tertiary Pond probably reflects the inputs of mill effluent and historic deposits of tailings solids. A more diverse benthic community is found amongst the emergent aquatic vegetation. Although the benthic community has been impaired by habitat damage it still provides a food base for the productive warmwater fish community of the creek.

The Balmer Creek fish community is dominated by warmwater species. The wide range of size and age classes of northern pike, walleye and white suckers in Balmer Creek suggests that the populations have not suffered from any serious toxic exposure causing reproductive failure. Although Balmer Creek provides spawning and rearing habitat, low numbers of young-of-the-year walleye, low numbers of female walleye and lack of any observed walleye spawning activity suggest some degree of reproductive impairment in Balmer Creek which may be due to the absence of high flowing waters in the creek, because of closure of the weir, during spawning season.

Cyprinids tested for fish tissue accumulation of mercury and arsenic showed that there is little to no accumulation of mercury or arsenic in fish which can be attributed to mining or milling operations.

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Pollutech Pollution Advisory Services Limited (1975) Water Quality Monitoring Program 1975. Campbell Red Lake Mines Limited Environmental Assessment Program (AQUAMIN Report No. 746).

Pollutech Pollution Advisory Services Limited (1975) Bioaccumulation of arsenic in fish tissue from the Red Lake Watershed and control lakes. Campbell Red Lake Mines Limited Environmental Assessment Program (AQUAMIN Report No. 747).

OMOE, Northwestern Region (1982) A chemical and biological assessment of waters impacted by active gold mining operation in the Red Lake area (AQUAMIN Report No. 495).

3 Kidd Creek Mines Limited

3.1 General Mine Site Description

3.1.1 Site Setting

- Kidd Creek copper-zinc-lead-silver mine is located in the Kidd Creek-Porcupine watershed located in the Townships of Hoyle and Matheson near Timmins, Ontario. The Porcupine area lies 350 miles due north of the city of Toronto and 70 miles northwest of Kirkland Lake (Figures 3.1 and 3.2).

- The surrounding area as characterized by *A Report on an Industrial Wastes Survey of the Porcupine District Mines*, is very flat, broken by low ridges and single hills up to 150 feet above average elevation, which is 1,000 feet. There is a high ridge along the southern boundary of the Township of Jamieson at an elevation of 1,350 feet.

- To the northwest, south, southwest and southeast the country is somewhat elevated, with more frequent rock outcrops than in the Timmins area where outcrops are sparse and only a few feet above grade and of very small area.

Figure 3.1: Location of Kidd Creek Mine

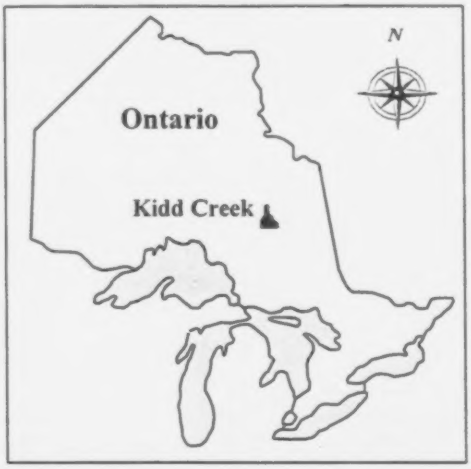
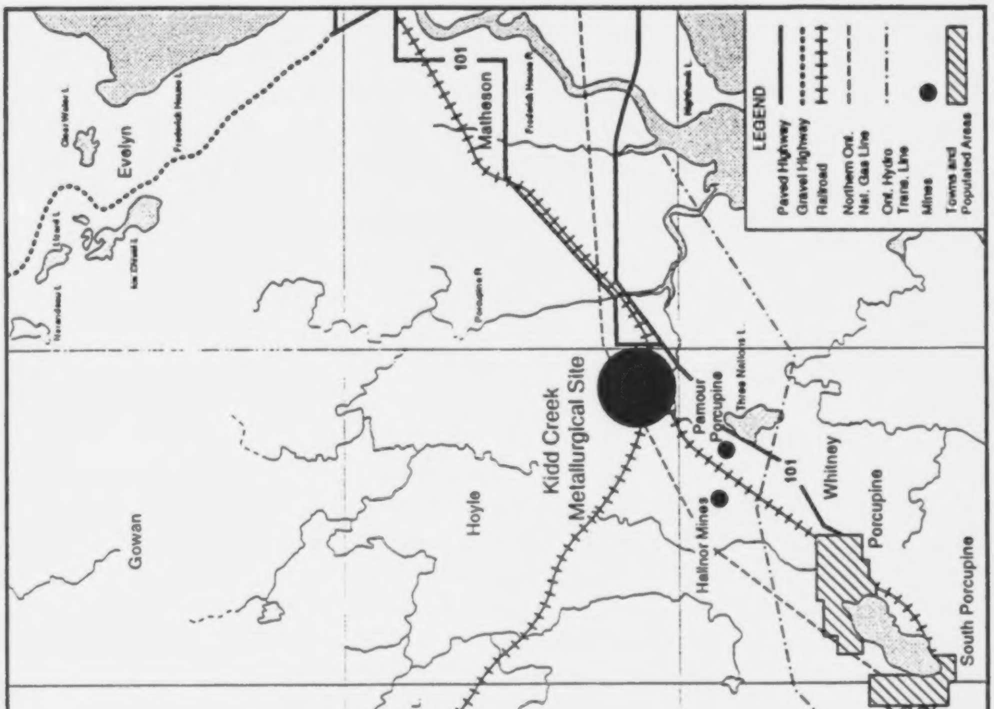


Figure 3.2: Kidd Creek Mine and Mill site locations


LEGEND
Paved Highway
Gravel Highway
Railroad
Northern Ont. Nat. Gas Line
Ont. Hydro Trans. Line
Mines
Towns and Populated Areas
Kidd Creek Mine Site
Kidd Creek Metallurgical Site
655
101
Evelyn
Matheson
Gowan
Hoyle
Pamour
Porcupine
Three Nations L.
Hallnor Mines
Whitney
Porcupine
South Porcupine
Wark
Murphy
Big Water L.
Little Goose L.
Feldman L.
Dome Mines
Schumacher
McIntyre Porcupine Mines
Hersey L.
Timmins
Timmins Airport
Kidd Creek
Kidd
Jessop
Mountjoy
Mattagami R.
Porcupine R.

3.1.2 Geology/Background Geochemistry

- The Porcupine area is located in the Townships of Hoyle and Matheson at the western productive end of the Abitibi Greenstone Belt. The bedrock consists largely of early Precambrian (Archean) age intermediate and mafic metavolcanics overlain by younger metasediments. The volcanics consist largely of mafic flows and pyroclastic rocks. The sediments consist of greywackes, siltstones, slates, argillites and minor pebble conglomerates.

- There are three generally east-west striking zones of mafic volcanic rocks subcropping in Hoyle and Matheson Townships. These zones are similar to each other in that they consist of variably carbonitized mafic volcanic flows enveloping intermittent narrow lenses of carbonate-bearing ultramafic rocks.

- Bedrock throughout Hoyle and Matheson Townships is extensively covered by overburden. This cover consists largely of thick sequences of glacial tills. The "Matheson Till" and other tills of the same Pleistocene age, is a very dense to medium dense sandy silt with 10 to 15% clasts and occasional sand stringers. These tills are overlain by "Barlow-Ojibway" age glaciolacustrine deepwater clay and till deposits. Minor scattered black muck and peat bogs cover the clays in both Hoyle and Matheson Townships.

3.1.3 History

- Inter-office Memo dated January 10, 1995, entitled "*Past and current dischargers to the Porcupine River System*" cites the Porcupine River System discharge history. The Porcupine River System, the receiving body of discharged effluent from the Kidd Creek operation, "[has] received several effluents from industrial sites including the Kidd Creek Metallurgical site. Historical discharges were received from several gold mines in the area including the Hallnor, Tisdale, and Owl Creek mines to name a few." The Owl Creek Mine had experienced significant acid mine drainage occurrence that had impacted the Porcupine River at one point. Many of the former dischargers are listed in the 1967 Ontario Water Resources Commission Report entitled "*Industrial Wastes Survey of the Porcupine District Mines*".

- The orebody of Kidd Creek Mines was discovered 23 km north of Timmins in 1964, at that time was owned and operated by Texasgulf Inc. Open pit mining of the deposit began in 1966 and the underground operations began in 1973. The ore is transported by rail from the mine site to the metallurgical site near Hoyle, approximately 20 km northeast of Timmins, Ontario. The concentrator at the metallurgical site has operated since 1966, produces primarily zinc, copper and lead concentrates.

- In 1968, the first full year of operation, 3.6 million tons of ore were processed to produce 562,400 tons of 52% zinc concentrates; 205,400 tons of 23% copper concentrates; 96,000 tons of lead concentrates; and 13,396,000 ounces of silver. In 1972, Texasgulf began operation of an electrolytic zinc plant (smelter and refinery) adjacent to the ore concentrator.

- The zinc plant started operation using the Tainton-Jephson batch leaching and purification circuit (electrolytic process designed to produce 120,000 tons/yr. zinc; 500 tons/yr. cadmium; 230,000 tons/yr. sulphuric acid; 24,000 tons/yr. silver-lead residue; and 1.000 tons/yr. cement copper.

- Following short term ownership by the Canada Development Corporation in the late '70s, Kidd Creek Mines Ltd. was acquisitioned becoming part of Falconbridge Limited in the early 1980s. The Kidd Metsite operation currently receives about 10,000 tonnes per day ore from the Minesite over a 20 mile (33 km) dedicated rail line.

- The metsite facilities include a concentrator, zinc complex (roast leach purify refine) copper smelter and refinery. A range of by-product and auxiliary facilities are also located on site including indium and cadmium plants, two acid plants and a variety of shops and service facilities. The operation also receives, stores and treats a range of custom feed and recycle materials by incorporation into the main process flowstream.

- Finished metal products zinc, copper, indium, cadmium, sulphuric acid and liquid sulphur dioxide are shipped to market together with, from time to time, copper and zinc concentrate surplus to current production.

3.1.4 Milling Methods

- The Kidd Creek concentrator processes 3.5 million tonnes of copper-zinc ore per year, coming by railroad from the minesite 2 km north of the concentrator. The ore grades 2.9% copper and 4.4% zinc and consists mainly of sphalerite, chalcopyrite, pyrite and a siliceous gangue. Copper-zinc Kidd "A" ore and Custom ore pass through a copper-zinc flotation circuit followed by separate concentrate handling systems to yield separate copper (25.7% Cu) and zinc (54% Zn) concentrates.

- The concentrator processes the ore through three identical divisions, A, B, and C. The basic control strategy used at the Kidd grinding circuits consists of maintaining: a) the rod mill density (82% solids), by a water-solid ratio controller, b) the cyclone overflow pulp density (50%), by manipulating the water flow rate to the cyclone feed pump-box, c) the rod mill ore feed (150 tph), by manipulation of the feeder slot openings. The percent solids in the ball mill is manually adjusted by manipulating the ball mill feed water flow rate, based on discontinuous Marcy scale readings.

- The zinc concentrate that grades 54% Zn and 0.6% Cu, mostly sphalerite, was processed in the electrolytic zinc plant that yields the following: finished zinc metal; copper cement to the smelter; 93/98% sulphuric acid; by-products of selenium sludge and cadmium metal; 0.1% sulphur dioxide off-gas; combined jarosite residues to the tailings; spent electrolyte and copper cement dust that are further treated at the dust treatment plant.

- The Kidd "A" and Custom copper concentrate that grades 25.7% Cu and 3.3% Zn, mostly chalcopyrite with some bornite, along with Kidd copper residues from dust treatment and cadmium plant as well as custom secondary feeds are processed in the copper smelter and refinery producing the following: commercial cathode and blister copper (98.5% Cu); selenium residue; 93/98% sulphuric acid; liquid sulphur dioxide; 0.05% sulphur dioxide off-gas; leached anode slimes; and C- and CL-slags (0.8% Cu).

3.1.5 Effluent

- Solid waste from all operations and liquid effluents are routed to a 1200 hectare tailing impoundment site (Figure 3.3).

- A *Report on an Industrial Wastes Survey of the Porcupine District Mines, August 1967*, cites the sampling and analysis of grab samples taken from both effluent from the impoundment area. The results indicated at the time of sampling, the effluents were acceptable for discharge to a watercourse.

3.1.6 Effluent Treatment

- The tailings from the concentrator (8000 tonnes per day) is mixed with jarosite from the zinc plant (240 tonne per day) for pumping to an external thickener located in the tailings area. Solids are thickened to a 65% solids pulp and discharged from a ramp near the centre of the site to form a thickened/cone (2% slope) with uniform size and mineralogical distribution and low hydraulic permeability.

Figure 3.3: Kidd Creek tailings and surface water drainage

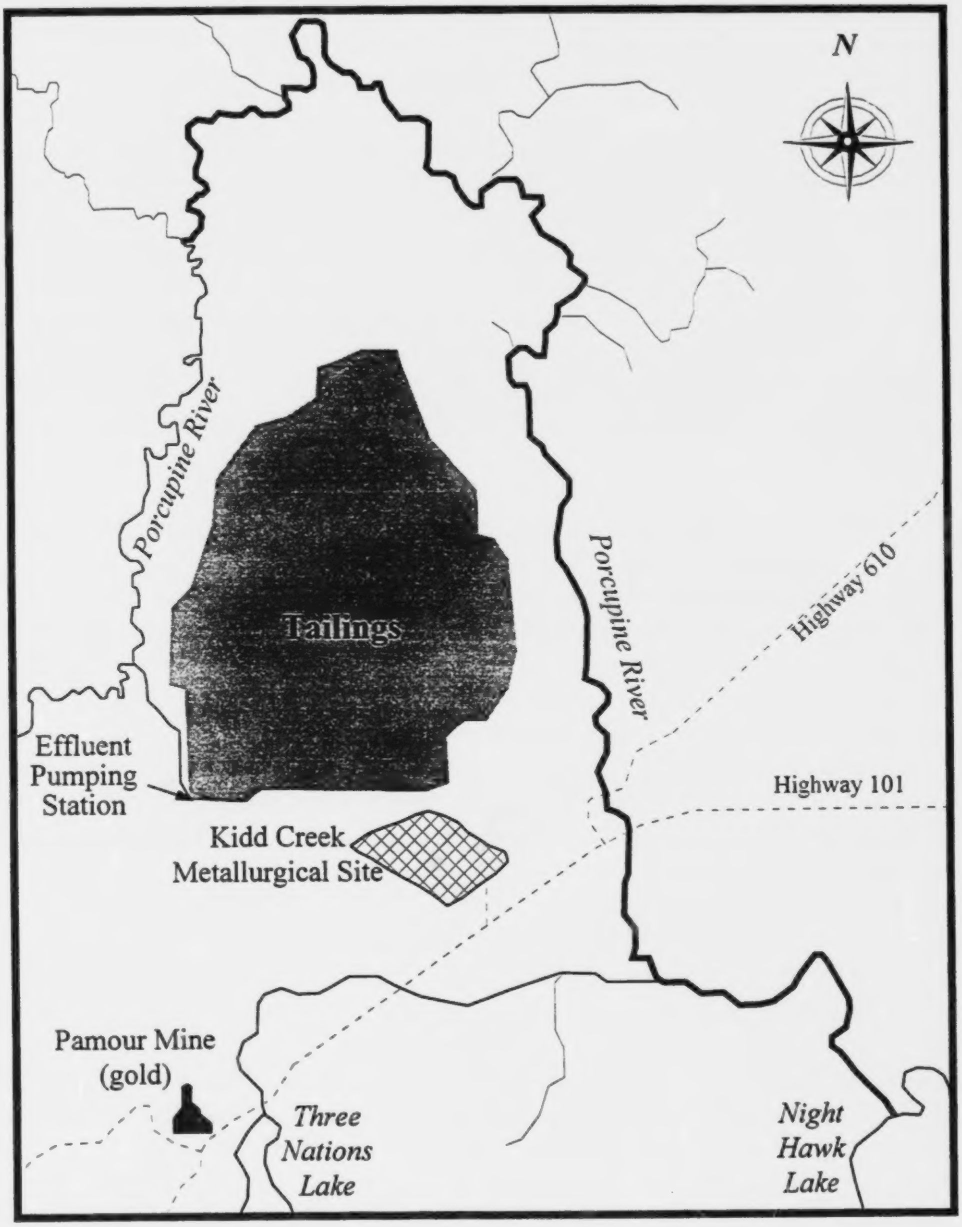
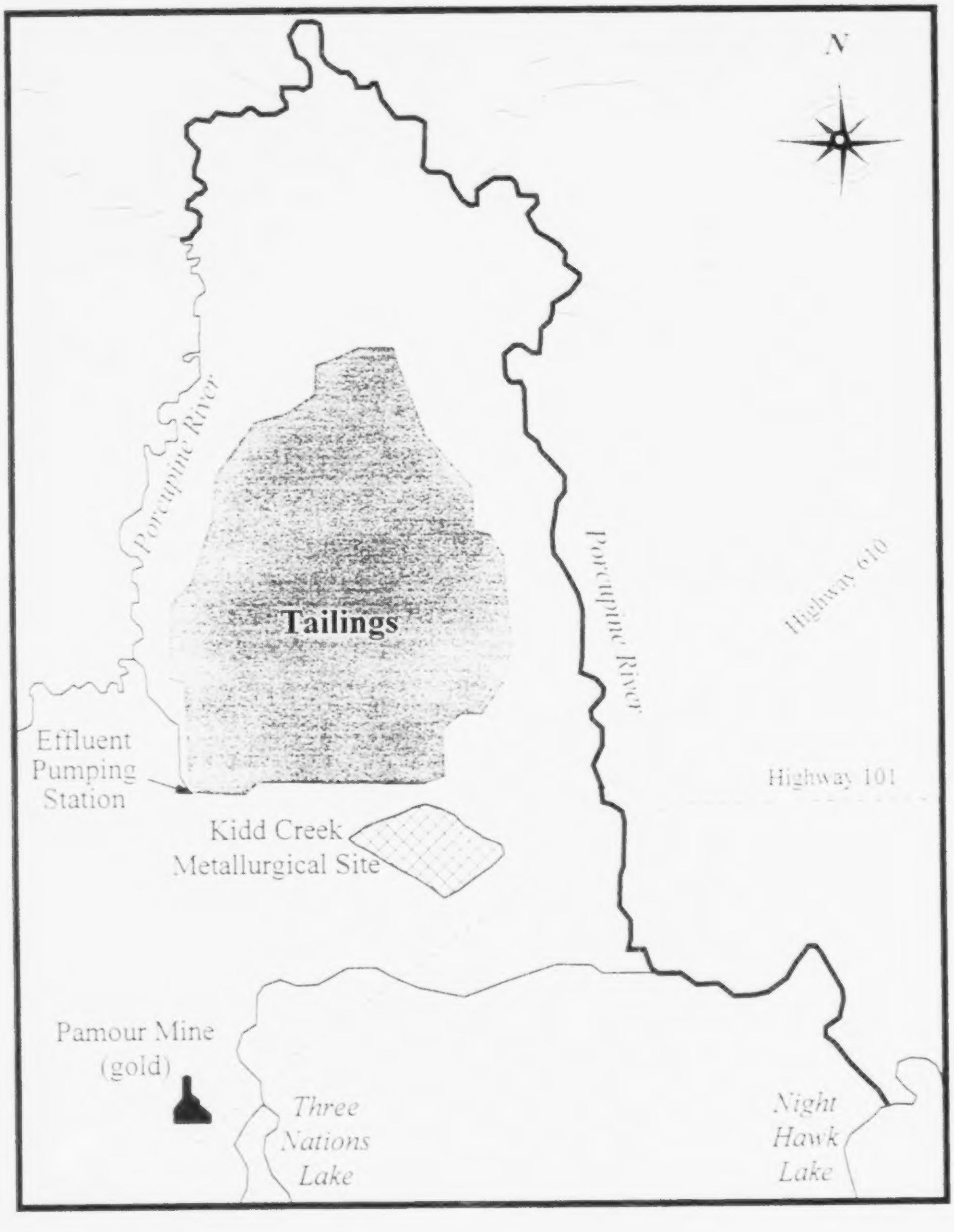

N
Porcupine River
Tailings
Porcupine River
Highway 610
Highway 101
Effluent Pumping Station
Kidd Creek Metallurgical Site
Pamour Mine (gold)
Three Nations Lake
Night Hawk Lake

Figure 3.3: Kidd Creek tailings and surface water drainage


N
Porcupine River
Tailings
Porcupine River
Highway 610
Effluent
Pumping
Station
Highway 101
Kidd Creek
Metallurgical Site
Pamour Mine
(gold)
Three
Nations
Lake
Night
Hawk
Lake

- A low berm delimits the boundary of the tailings area and water overflowing the thickener runs in a channel around the periphery of the cone just inside the berm to a surge pond ("C"). The pond discharges down a short flume where hydrated lime is added and mixed to neutralize acid and precipitates base metals, principally zinc.

- The gypsum/metal hydroxide precipitate settles in a further pond ("D") and a clear overflow discharges via a MISA (Municipal and Industrial Strategy for Abatement) control point to the Porcupine River. A second pond ("A") takes a variety of process plant effluents for treatment in a separate neutralizing system that also discharges to pond ("D"). The low density gypsum/metal hydroxide sludge that accumulates settling in pond ("D") is periodically transferred by a dredge to the main tailing cone.

- The MISA control point incorporates a sampling and monitoring station where water samples for chemical analysis and biological testing are obtained and pH is monitored.

3.1.7 Seepages/Runoff

- Report #721 cited an iron plume in the Porcupine River approximately 4.7 km upstream of the Kidd Creek effluent. Investigation revealed that leachate from a waste rock pile was draining through Owl Creek into the Porcupine River. Falconbridge Gold owned the waste rock pile and took remedial action by diverting Owl Creek and keeping the water on the property. This property is now owned by the Kinross Gold Corporation. Sampling of Owl Creek following the diversion indicates that Station #51 is still a source of Cu (27 μg/L), Ni (41 μg/L), Zn (76 μg/L), Fe (2200 μg/L) and Al (350 μg/L) following the diversion. At Station #52, approximately 200 m downstream, Ni and Cu were diluted to near background levels, however, Fe and Al contamination continued downstream of the Kidd effluent.

3.1.8 Compliance Record

- The Certificate of Approval (C of A) requires that Falconbridge -- Kidd Creek Division design, construct and operate the sewage works such that the effluent concentrations of the parameters listed are not exceeded in the effluent from the final effluent basin to the Porcupine River. Concentration limits are given for both daily and monthly endpoints in mg/L for total cyanide, total suspended solids, copper, lead, nickel, zinc and arsenic. Furthermore, it requires that pH of the effluent be maintained within the range of 6.0 to 9.5, inclusive at all times.

- Report #703, *Report on an Environmental Survey of the Porcupine River, June 1974* mentions that results from their benthic fauna survey showed a reduction of the fauna diversity from previous surveys. Zinc concentrations remained high (0.25 mg/L Zn) in the lagoon discharge, with generally low concentrations of other metals found comparable to concentrations found in the northwest branch of the Porcupine River.

- Report #692, *Report on an Environmental Survey of the Porcupine River, June 1975* cites significant zinc concentrations in the lagoon discharge of 0.25 mg/L. It further stated that the zinc had an adverse effect on the aquatic environment due the observed differences in the benthic fauna at Stations 1 and 3.

- Report #704, *Report on the Biological Survey of the Porcupine River for the Month of June 1975*, indicated that improvements have occurred in the watershed from previous reports. It notes an improvement in the river system from results of the benthic fauna survey. Furthermore, it notes lower zinc concentrations in the final effluent at Station 2 from previous years.

- Reported water quality in the feeder stream that receives effluent from Kidd Creek and drains into the Porcupine River exceeded Provincial Water Quality Objectives (PWQO) for Zn, Cd, Se, and Cu during June and August 1990 sampling according to Report #721 from the Ontario Ministry of Environment Results from waste rock runoff water was allowed.

3.1.9 Acid Mine Drainage

- Report entitled "*Thiosalt Decomposition*" and the memorandum concerning "*Thiosalt Levels in Metsite Final Effluent*" indicate that the potential for acid mine drainage is real. Thiosalt levels entering the final polishing pond are currently monitored year round on a weekly basis. Sources of thiosalt generation have been documented in various mill surveys that indicated 99% of thiosalt generation occurred during primary grinding of the ore.

- Thiosalt levels discharged to tailings decreased as the effluent passed through the tailings system, with complete oxidation occurring before final discharge in surveys conducted in July and November 1991.

3.1.10 Physical Disturbance

- A *Report on an Industrial Wastes Survey of the Porcupine District Mines, August 1967*, cites the removal of a quantity of timber from the tailings area site, but much still remains. The dams were constructed using locally found material and raises were carried out using the coarse sands deposited on the inside slopes. At that time, the company did not demonstrate their rehabilitation program intended for the area. The Report concluded that "the company should institute such a programme immediately".

3.2 Description of Quality and Quantity of Information for the Mine Site

3.2.1 Study/Experimental Design Adequate

- The Certificate of Approval issued under the *Ontario Water Resources Act (OWRA)* under the MISA program requires that Falconbridge -- Kidd Creek Division carry out the following monitoring program:

  1) all samples and measurements taken for the purpose of this certificate are taken at a time and in a location characteristic of the quality and quantity of the effluent stream over the time period being monitored.

  2) samples shall be collected and analyzed at the following sampling point, sampling frequencies and sample type specified for each parameter listed.

Parameter	Frequency			Sample Type
	Daily	Weekly	Quarterly	
pH	X			grab
total suspended solids	X			grab
copper		X		grab
lead		X		grab
nickel		X		grab
zinc		X		grab
arsenic		X		grab
acute lethality			X	grab

- Quality assurance/quality control (QA/QC) work has been conducted by the analytical laboratory since 1985. The bulk of the QC work has been interlaboratory round robins.

The round robins are part of a performance evaluation under the analytical quality assurance program of the occupational health chemists section of the Association of the Chemical Profession of Ontario (ACPO) since 1991. Methods use for the evaluations since 1985 is indicative of the performance of the environmental analysis work as similar methods were used for the determinations from an instrumentation and analysis method perspective.

- As required by the Ontario Ministry of the Environment and Energy, as part of the MISA obligation, the QA/QC requirements were adopted within Kidd Creek's protocols including sampling.

3.3 Results of Aquatic Effects Assessment

3.3.1 Water Quality

- At present, the sewage treatment works from the city of South Porcupine discharges to the Porcupine River; which eventually receives effluent of the Pamour gold mine. These discharges are upstream of the Kidd Creek final effluent. Downstream of the Kidd Creek discharge point, the Bell Creek mine discharge is received from the North Porcupine River.

- Inter-office Memo dated January 10, 1995, entitled "*Past and current dischargers to the Porcupine River System*" cites the Porcupine River System discharge history. The memo describes the Porcupine River System. It includes the "Porcupine River [that] flows from Porcupine Lake, eventually reaching the Nighthawk Lake system. Tributaries to the Porcupine River include Bell Creek which flows to the North Porcupine River which flows into the Porcupine River. Owl Creek discharges to the Porcupine River and Three Nations Creek also joins the Porcupine River just before it reaches Nighthawk Lake." Refer to Figure 3.1.

- The Certificate of Approval issued under the *Ontario Water Resources Act (OWRA)* under the MISA program established the water quality criteria in addition to the monitoring requirements of the Kidd Creek operation. The criteria, in conjunction with site-specific factors concerning intended water use and ambient water quality, have been used to develop Ontario MISA Water Quality Objectives for the Porcupine River drainages.

- Reports #703 and #692 do not have any assessment of data quality for the 1974-75 monitoring program. Hence, there is no assessment of sampling precision or blank quality, or analytical precision and accuracy provided. Therefore, the accuracy and reproducibility of these data may not be adequate for comparison with water quality objectives or between sites.

- No quality assurance data is reported for the values presented in Reports #704, #660 and #722 by Fontana (1975, 1980 and 1981), so a similar caveat applies to water quality data interpretation.

- Report #708 describes the course the Porcupine River takes. It passes on three sides of the Kidd Creek metallurgical plant 24 km northeast of Timmins. It leaves Porcupine Lake at Highway 101 and flows northward on the west side of the plant complex. Then, it turns southward to pass the east border of the metsite. It then continues past the town of Hoyle and onto discharge into Nighthawk Lake.

- Report #708 (1982) fails to report any quality assurance data for the values represented in it, hence, a similar caveat applies for any data interpretation.

- Report #658 (1982) describes the methodology, results and conclusions of an environmental survey of Kidd Creek. Both water and benthic samples were collected at various locations along the drainage system. However, this report fails to report any quality assurance data for values represented in it. Results obtained were similar to those of previous surveys, with notable differences in water quality between stations K2 and K3 regarding increased pH, conductivity, alkalinity, total hardness, sulphate, nitrate and zinc ion concentrations. However, without data quality the precision and reproducibility of the sampling protocols as well as the analytical techniques; the differences in the results may be attributed to a myriad of sources.

- Report #714 cites multiple sampling of both benthic and water samples. Figure 2 of the report, lists the chemical components of the water sampled at the nine stations along the Porcupine River. Furthermore, the report indicated that the levels of heavy metals such as zinc and some other chemicals in the effluent were found to be above average surface waters. Zinc was quoted at 10 μg/L, iron at 40 μg/L. Both concentrations at site two were reported as being above average, but iron was high at site one located before the input of effluent.

- Report #688 mentioned that "the May 1989 water quality data from the Kidd Creek drainage system indicate that there is little or no impact of the Kidd Creek Mine discharge on the receiving waters".

- Reported water quality in the feeder stream that receives effluent from Kidd Creek and drains into the Porcupine River exceeded Provincial Water Quality Objectives (PWQO) for Zn, Cd, Se, and Cu during June and August 1990 sampling according to Report #721 from the Ontario Ministry of Environment. "August readings were high in total solids (2470 mg/L) and total dissolved solids (2463 mg/L) resulting in high conductivity. Sulphate levels were high (1308-2000 mg/L) and pH (6.1-6.3) was reduced from actual effluent values (8.2-8.9, 1989 IMIS data)."

- Report #721 mentioned that the August 1990 water sampling showed that episodic events of high pH, major ions, zinc and selenium do occur from the Kidd Creek effluent. The report concluded that, "These changes in the water chemistry would be enough to cause mortality or avoidance in benthic organisms."
- "The analytical results for the 1992 survey show that the effluent from the minesite had little effect on Kidd Creek water quality. The results of the 1992 survey and historic surveys show that there was little apparent environmental stress on the Kidd Creek system." Report #680 also concluded that the parameters that were present in concentrations higher than background in the Porcupine River stations, downstream of the final effluent creek include: conductivity, hardness, total dissolved solids, sulphate and calcium.
- Inter-office memo entitled "*November 1994 Kidd Metsite/Minesite Effluent Water Quality*" mentioned that the MISA Mining Regulation came into effect for monitoring requirements on November 24, 1994. Consequently, data for total cyanide will be reported from that date. Effluent limit requirements contained in the regulation become effective in August 1997.
- The above memo further cites that except for pH, the MISA monthly limits for all parameters were met at both the Kidd Metsite and the Minesite. "Applications of pH control measures are currently being established with the installation of the carbon dioxide treatment system."

3.3.2 Sediment Quality

- Report #721 was the only report containing sediment quality data. Triplicate grab Ekman samples were taken at each site.

3.3.3 Benthic Macroinvertebrates

- Benthic surveys have been done since 1973 on Kidd Creek to determine if there are impacts from the mining operations. The reports provided for review spanned a time period from 1980 to 1993 but included discussions of data from surveys dating back to

1973. Some studies were done in October and some in June so there was an attempt to capture seasonal variation.

- The study design was basically the same for all the studied except Report #187, the 1993 study which will be dealt with separately since it incorporated a lot of improvements in both study design and data analysis that was needed in the older surveys. For surveys up to and including 1992, there were two sites upstream of the discharge, one at the minesite effluent discharge and five sites downstream of the discharge, making a total of eight locations. The same sites were sampled for all the surveys using an Ekman sampler.

- For all but the 1989 and 1992 surveys, three Ekman grabs were taken and combined to form one sample. In 1989 and 1992, 4 grabs were to form one sample. Only one sample was taken at each site. The number of sites sampled was acceptable with two reference upstream stations and exposure stations at varying distances from the point of discharge.

- Report #187, (Water Systems Analysts, October 1993) entitled "*Effects of the Kidd Copper Mine on Aquatic Macroinvertebrate Benthic Communities*" was different in most respects from the previous studies. The purpose of the study was to evaluate the extent of water quality effects due to mine tailings. The study focused on the major receiving waters on the mine site. Specific areas of interest were the creek upstream of Perch Lake, Perch Lake, the creek downstream of Perch Lake past the eroded tailings fan and near the culvert where the creek passes under Regional Road 4. Habitat information for all sampling locations was noted. Habitat conditions in reference and exposed stations were similar in terms of water depth and flow. There were differences in substrate composition that were recorded for consideration in analysis of results.

- Six Ekman grab samples were collected at each sampling area, washed through a 500 μm mesh and immediately preserved in 10% buffered formalin. Details of sample handling in the lab were given and a reference given for the procedures used in taxonomic identification. Community structure was assessed using non-metric multidimensional scaling on organisms that accounted for greater than 5% of the total number in at least two samples. Correlations between sample scores on each dimension from the NMDS solution and the individual taxon abundances were calculated to determine which of the taxa could be considered important in separating communities among stations. Because replicate samples were taken at each site, it was possible to use Analysis of Variance (ANOVA) and multivariate ANOVA to test for significant differences in benthic communities among stations. Further statistical calculations to estimate why there were differences were also enabled.

- The survey programme for the Porcupine River was initiated in 1971 by Texasgulf

Canada Ltd. The reports provided for review spanned the time period from 1974 to 1992. The study design was basically the same for all the surveys with changes and additions to sampling location in some years. Studies were done in May-June or October of any given year.

- All surveys done by Kidd Creek mines in the Porcupine River System had consistent sampling locations over the years with additional stations added in later years. There were several control stations, two upstream of the Kidd discharge and one on the northwest branch of the Porcupine River upstream of the confluence with the southwest branch. The exposure stations were located at varying distances downstream from the discharge ranging from one located right at the discharge to a site on the southwest branch of the river about 6 km downstream of the discharge.

- The upstream control stations were not pristine since they were downstream of other pollution sources indicated on the map of the study area. The habitat description at the various sites was limited and obviously habitat similarities were not considered in the choice of reference locations.

- Sediment grab samples were taken using an Ekman sampler. Each sample was a composite of 3 grabs and four samples were taken at all sites except at the discharge. For the 1989 and 1992 studies, a four grab composite was used.

- Report #721, Ontario Ministry of Environment and Energy (MOEE) Technical memo dated October 23, 1990 describes a benthic, sediment and water quality study conducted by MOEE in June/Aug 1989. Ekman grab samples were taken for benthic community analysis and sediment quality analyses. Triplicate samples were taken at each site. Substrate cages filled with 3-7 cm diameter rocks were also set in June and retrieved in August. The same stations used in the above surveys as well as two additional control stations were sampled. No statistical analysis or diversity indices were calculated. The data was presented as total number of taxa and abundance of different organisms. No organisms were found at the first two downstream stations in June and low numbers of chironomids were found at these sites in August. Diversity and abundance were found to be lower at all downstream locations as compared to the furthest upstream station.

3.3.4 Fisheries

- No information was presented on fish in the 29 reports provided on Kidd Creek operations at the mine and the metallurgical sites.

3.3.5 Toxicity Testing

- Information presented on toxicity testing indicates that tests were conducted on effluent samples collected over three time periods: November 26, 1990 to April 1, 1991; September 22, 1992 to December 16, 1992; and March 22, 1993 to May 26, 1993.

- During the first period, three tests were conducted using rainbow trout, fathead minnows, and *Daphnia magna* on effluent samples from the metsite. Organisms were exposed to full strength (100%) effluents with and without pH adjustments. Information on the unadjusted pHs was presented for two of the three effluent samples indicating that pHs were 10.5 and 11.0. These unadjusted pH effluent samples produced 100% mortality in all three organisms. For rainbow trout, lethality began at about pH 9.5, and for fathead minnow and *Daphnia magna* lethality occurred between pH 10.0 and 10.5.

- A simple, but sound, proposal to evaluate whether unionized ammonia was contributing to the lethality was presented on December 15, 1990 by one of the contractors. Presumably this proposal was never funded, because no subsequent information is provided on results. This is unfortunate because analyses of effluent collected on September 22, 1992 show that ammonia-nitrogen is present at 0.2 mg/L, a concentration that would contribute to acute lethality at high pHs.

- During the second period, four tests were conducted using rainbow trout and *Daphia magna* on pH-adjusted effluents only from the metsite and the mine site. Before acidification, the pH values for the metsite effluents were 9.03, 9.60, 11.30 and 11.28; and for the mine site effluents, the unadjusted pHs were 10.89, 11.07, 11.63 and 11.58. No mortalities were observed in either species when exposed to effluents with pH adjusted to 9.0.

- During the third period, static toxicity testing for 96 hours at 15^0 C using rainbow trout was conducted on effluents from the metsite and the mine site. Statements are made that testing was in keeping with the proposed MISA regulations, and that procedures followed the July 1983 OMOE "Protocol to Determine the Acute Lethality to Liquid Effluents to Fish". Again, pH-unadjusted effluents, having pHs of 10.9 (metsite) to 11.5 (mine site), tested at full strength (100%) produced complete lethality in a short period of time (1.0 to 1.5 hours). A 50% dilution of the metsite effluent had a pH of 8.9 and did not produce mortality; whereas, a 50% dilution of the mine site effluent had a pH of 11.1 and produced 100% mortality in 18 hours. Use of 75% dilution water and 25% mine site effluent produced a pH of 10.4 and 25% mortality at 96 hours. Adjustment of pH to 9.0 and below using CO_2 or H_2SO_4 of both metsite and mine site effluents resulted in no mortality after 96 hours of exposure.

3.4 Discussion

3.4.1 Evidence for Aquatic Effects

3.4.1.1 Effects on Use of Water

- The Kidd Creek Mines operations did change the water quality in the streams and Kidd Creek and Porcupine River Systems. Reported water quality in the feeder stream that receives effluent from Kidd Creek and drains into the Porcupine River exceeded Provincial Water Quality Objectives (PWQO) for Zn, Cd, Se, and Cu during June and August 1990 sampling according to Report #721 from the Ontario Ministry of Environment Results from waste rock runoff water was allowed.

- Report #721 concluded that the contamination of the Porcupine River caused by Owl Creek, made it difficult to isolate the impact of the Kidd Creek effluent itself. Fingerprint parameters which distinguished Kidd Creek effluent from Owl Creek leachate were sulphate, zinc and selenium. The August 1990 water sampling showed that episodic events of high pH, major ions, zinc and selenium do occur from the Kidd Creek effluent. The report concluded that, "These changes in the water chemistry would be enough to cause mortality or avoidance in benthic organisms."

- The above report outlined that the effluent must be reduced to achieve PWQO or (background levels at Station #6) at Station #3 the flow of the Porcupine River must be determined upstream of the effluent. Monthly flows should be determined by the company and calculations made to determine the maximum concentration possible in the effluent to achieve PWQO at Station #3. Owl Creek exceeded PWQO in Cu, Ni, Zn, Fe and Al values. Fe, Cu and Al continued to exceed PWQO downstream of Owl Creek.

- The 1993 study on effects of the Kidd Creek tailings effluent showed that the benthic community was impacted by mine operations since certain groups thought to be sensitive to mixed metal mine waste were only found at control sites.

3.4.1.2 Effects on Sediments

- The sites upstream of the Kidd Creek discharge were higher in Cu, Ni, Zn, Fe, Al and loss on ignition (LOI) than the downstream stations. Downstream stations showed higher Pb, Cd, and Se than the upstream stations. Averages and standard deviations were calculated for all sites. Cu, Ni, Zn and Cd concentrations at all stations greatly exceeded the lowest effect levels stated in the MOEE Provincial Sediment Quality Guidelines (1992). Pb concentrations exceeded the lowest effect level at the first two downstream stations and maybe contributing to causing the low abundance of benthic organisms observed. The exceedance of the lowest effect levels stated in the Provincial Sediment Quality Guidelines indicates the potential to affect aquatic life. The Pb loadings appear to be associated with the Kidd Creek metallurgical site effluent.

3.4.1.3 Effects on the Benthic Environment

- In reports up until 1982, it was concluded based on limited data analysis with no consideration of habitat differences that the mine discharge to Kidd Creek was possibly having impacts on the benthic communities immediately downstream, since low species diversity and abundance were observed at the first two downstream stations.

- The 1989 biological survey concluded that there were minimal effects based on calculations of Shannon-Weiner Indices (SWI) for different sites. The highest SWI value occurred at the discharge itself, which indicates that this index was not a reliable measure of water quality for this system probably because abundance was so low. Examination of the raw data shows that sensitive species were absent at the immediate downstream sites but present at the sites close to the confluence of the Mattagami River. In the 1992, Lakefield Research based on their analyses, concluded that Kidd Creek environmental conditions had not deteriorated over the last 18 years and did not appear to be under severe environmental stresses except at Station K4, where the low productivity is probably due to the clay substrate.

- Report #187 study concluded that based on variations observed between reference and exposure areas that the mine has effects on water quality as far as the southernmost station sampled and within the beaver pond southwest of the town site. Many taxa found in the control site were not present in the exposed sites. While some of the organisms maybe absent because of substrate differences the varied lifestyles of the organisms absent in the exposed areas suggests that the differences are due mainly to water quality differences. Also, certain groups thought to be more sensitive to mixed metal mine waste were only found at the reference location.

- There were conflicting conclusions on whether the metallurgical site effluent discharge was impacting the benthic community. The different conclusions appeared to be a direct result of the extent of analysis done and the type of community evaluation index used. In the reports up to 1985, the general conclusion based on calculations of coefficients of similarity, diversity and biotic indices was that there were impacts at downstream locations since there was an absence of pollution sensitive organisms and low diversity at the first three downstream sites relative to the two control sites. The community began to show recovery at about 4 km downstream of the effluent discharge. This conclusion was made with no consideration of differences that could have resulted from differing habitat at sampling sites and species habitat preferences.

- In 1989, based on calculation on Shannon-Weiner index values, it was concluded that no negative impacts of the Metsite discharge could be identified. This index had its highest value at the discharge and from looking at the raw data, was not representative of the quality of the benthic community. A suite of different indices must be used to avoid erroneous conclusions. Even though reduced diversity and abundance was observed at downstream exposed sites, without adequate analysis of the significance of these differences and the potential influence of microhabitat factors, definite conclusions cannot be drawn.

- In 1992, no organisms were found at the metsite effluent discharge site. This may indicate acute lethality of the metsite effluent. In earlier studies on the Porcupine River, there were habitat differences among sites, so even though there was reduced benthic diversity and abundance at sites immediately downstream of the metsite discharge definite conclusions on the cause of this reduction could not be drawn on the metallurgical site.

3.4.1.4 Effects on Fish

- Over the periods of operation of the mine and metallurgical sites, no data have been obtained on fish populations and communities in waterways affected by these Kidd Creek operations, on contaminant concentrations in resident fish, and on adverse effects on these fish.

3.4.2 Effectiveness of the MMLER and Provincial Regulatory System

- Adequate data are not presented for assessing the effectiveness of federal and provincial regulations for protecting the health of resident fish stocks and of human consumers of those fish.

- Sufficient baseline information was not obtained prior to the onset of mining and milling operations to assess whether changes have occurred in resident fish stocks.

- The MISA Mining Regulation Limits for Zn, As, Ni, Pb, and Cu are considerably higher than the Water Quality Guidelines for the protection of freshwater aquatic life.

3.4.3 Assessment of Monitoring Program Adequacy

- Further sediment quality studies need to be done and sources of the different metals identified.

- Comments on the adequacy of monitoring and recommendations for future work are the same for both the Kidd Creek system and Porcupine River studies. The major problem with the surveys conducted from 1980 to 1992, was the limited consideration given to habitat variables such as water depth, flow rates, sediment particle size and nature, macrophyte cover, proximity to tributary outflow. The habitat strongly influences the benthic community present and it is essential to eliminate the habitat variability when attempting to establish the impacts of the mine discharge on the aquatic biota. Ideally, reference locations should possess habitat characteristics similar to those of the exposure locations. There were differences in substrate type and flow between exposure and reference areas that could have lead to some of the variation detected in the benthic communities. Because of habitat variability and insufficient numbers of replicates for thorough statistical analyses, no definite cause/effect relationships could be established from the data.

- For further studies, detailed habitat assessment should be conducted and suitable reference areas chosen. Studies should be done to determine the extent of the effluent zone and effluent concentrations at the sampling stations. Sufficient samples should be taken to allow use of appropriate statistics to determine spatial variation within and between sampling areas as well as temporal variations. If indices are used to determine community structure, a suite of different ones should be used, which include diversity, evenness, richness, dominance and similarity. Habitat preferences of different species should be considered when establishing cause/effect linkages. Sediment quality studies should be included in future monitoring programs. Report #187 study was well designed and further studies should follow this example.

- Isopropyl alcohol was used to preserve the benthic organisms for identification for all except the 1993 study, Report #187 and since it does not function as a fixative, this may have led to poor identification of crushed animals in past surveys. Buffered formalin is recommended as a fixative.

- Toxicity testing of effluents from both the metsite and mine site demonstrated overt, alkaline pH-dependent toxicity of these effluents to rainbow trout, fathead minnows and *Daphnia magna*. Although acidification of these effluents reduced toxicity in the laboratory, information was not presented on whether final effluents are acidified before discharge. No attempts have been made to identify whether other contaminants, i.e., ammonia or metals, are contributing to the acute lethality.

- To improve the shortcomings described in Evidence for Aquatic Effects, the following actions should be taken:

  1) Use "*Final Effluent Analysis Results*" required under MISA in combination with data on volumes of effluents discharged to calculate actual contaminant **loadings to receiving waters**.

  2) Verify these calculations and define the extent and area of affected aquatic habitat by determining contaminant concentrations in sediments of impacted watersheds. Because sufficient information was not obtained prior to the onset of mining and milling operations, obtain, where possible, sediment cores and analyze sections of these cores for contaminants to determine a history of discharge.

  3) Determine the **biological availability** of these contaminants to resident fish by collecting a statistically appropriate number of these fish (viz. 10 males and 10 females) per site, and analyze their kidneys, livers, gills, and muscles for contaminants.

  4) Evaluate sublethal, adverse effects on the health of these fish by using procedures, i.e., metallothionein and histopathology, as defined in the current Aquatic Effects Technology Evaluation (AETE) Program.

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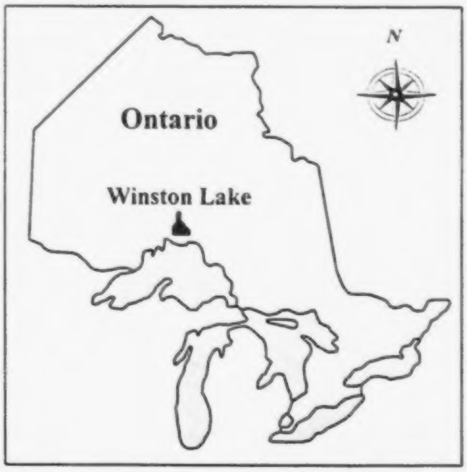
4 Winston Lake Mine

4.1 General Mine Site Description

4.1.1 Site Setting

- The Winston Lake zinc-copper mine and mill complex is located approximately 20 km northwest of Schreiber, Ontario, which is approximately 210 km east of Thunder Bay, Ontario on Highway #17 on the north shore or Lake Superior on the headwaters of the Whitesand River watershed. The minesite location is shown in Figures 4.1 and 4.2.

Figure 4.1: Location of the Winston Lake Mine



- The surrounding area as characterised by "*Impact of the Zenmac Mine on the Whitesand River Water Quality*", the 135 km^2 Whitesand River watershed reports to Lake Superior through a chain of small lakes and through the Rainbow Provincial Park (Figure 4.3). The chain of lakes, that are part of the Whitesand River and are relevant to existing and past mining activities, begins with Kenabic Lake and proceeds in sequence through Cleaver Lake, Gumboot Lake, Hornblende Lake, Lyne Lake and ends with Whitesand Lake. Winston Lake drains into Cleaver Lake, and Ross Lake drains into Lyne Lake. Surface areas for Kenabic, Cleaver, Gumboot and Hornblende lakes are 1.5, 11, 10.5 and 22 hectares, respectively. Lyne, Ross and Whitesand lakes are much larger. Depth contour maps provided for Cleaver and Hornblende lakes show that both lakes have a

Figure 4.2: The Winston Lake Mine and the Whitesand River watershed

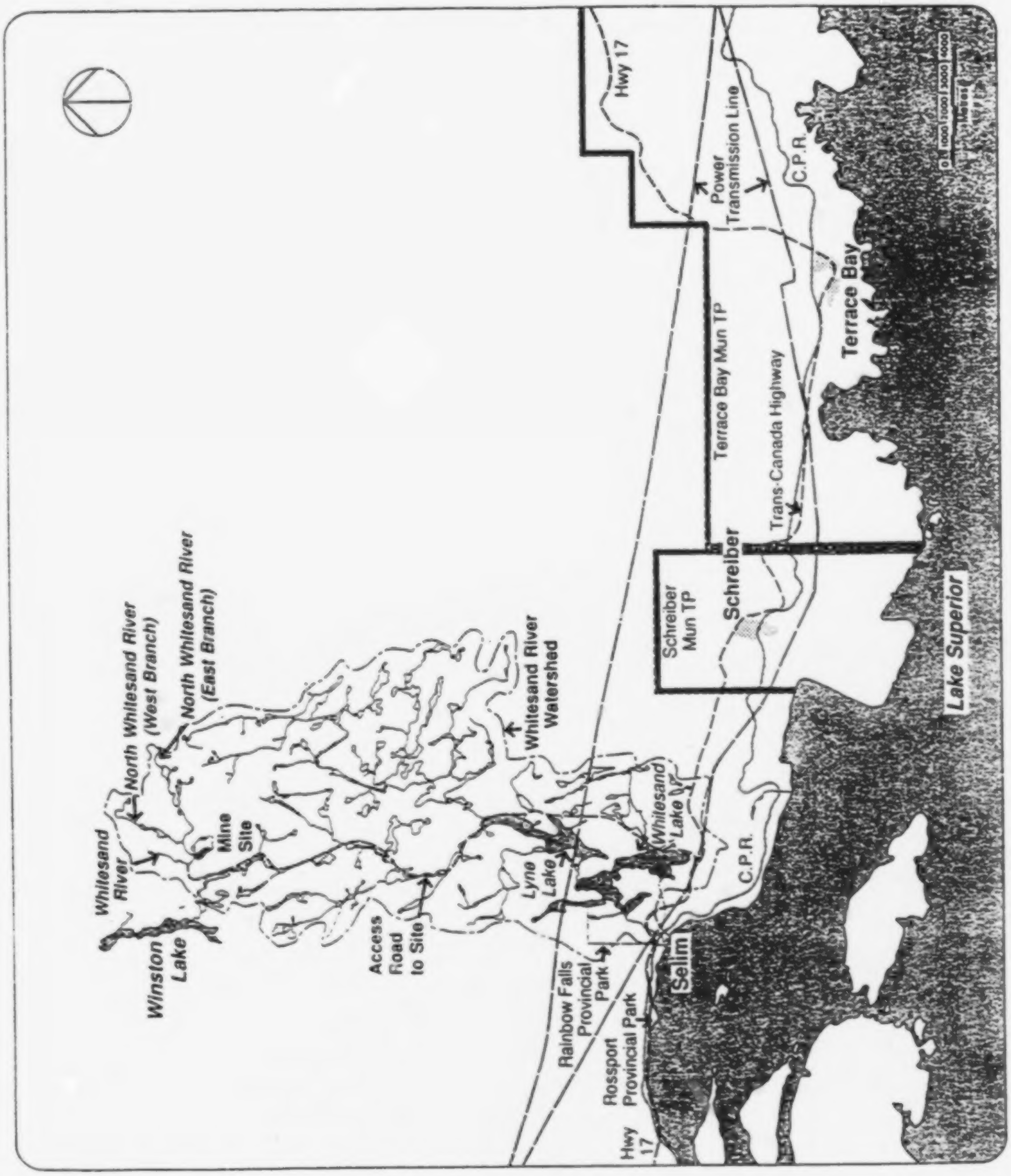
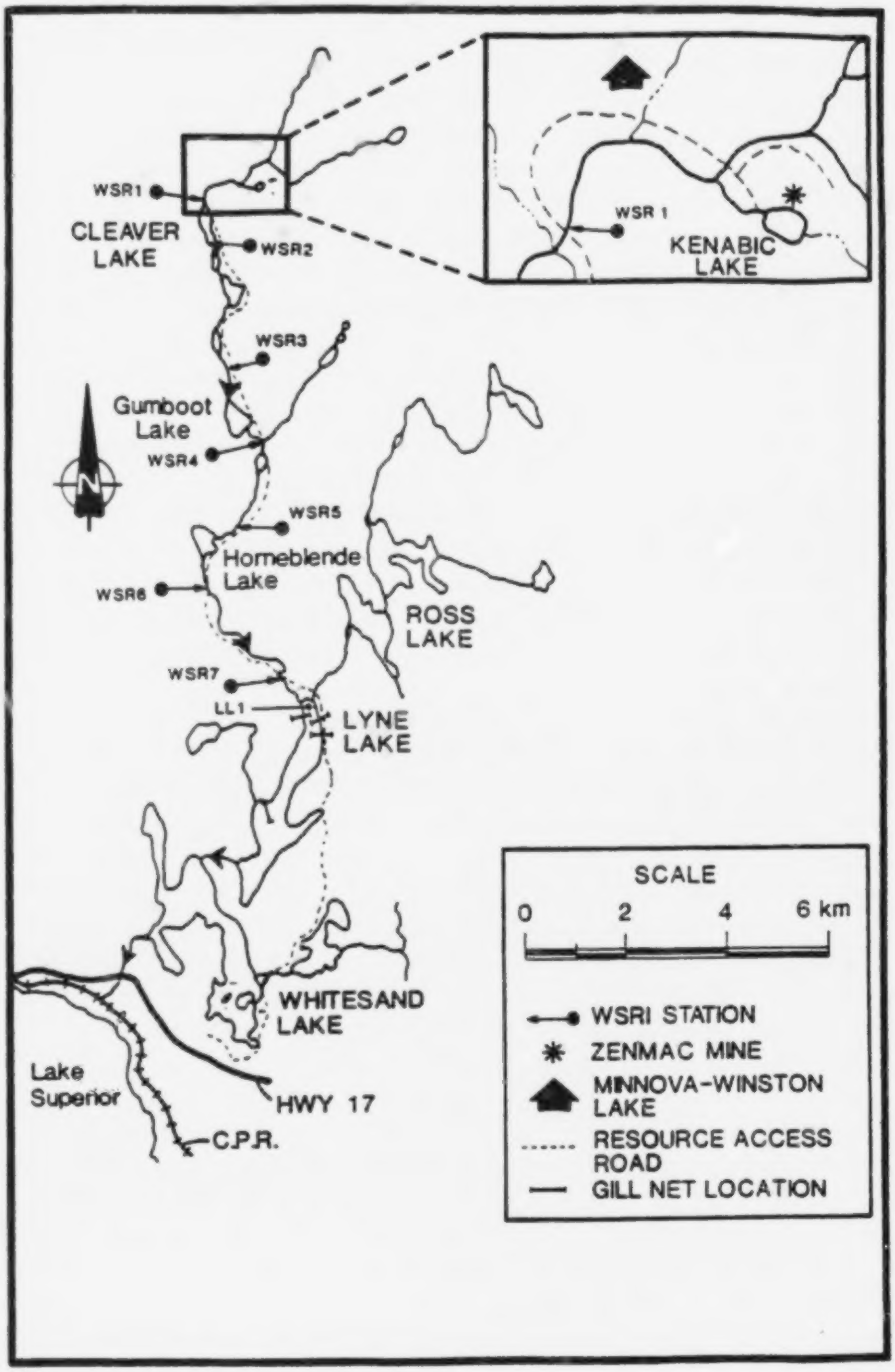

Winston Lake
Whitesand River
North Whitesand River (West Branch)
North Whitesand River (East Branch)
Mine Site
Access Road to Site
Whitesand River Watershed
Lyne Lake
Whitesand Lake
Rainbow Falls Provincial Park
Rossport Provincial Park
Hwy 17
Selim
C.P.R.
Schreiber Mun TP
Schreiber
Trans-Canada Highway
Terrace Bay Mun TP
Terrace Bay
Power Transmission Line
C.P.R.
Hwy 17
Lake Superior
0 1000 2000 3000 4000
metres

Figure 4.3: The Whitesand River watershed


WSR1
CLEAVER LAKE
WSR2
WSR3
Gumboot Lake
WSR4
N
WSR5
Horneblende Lake
WSR6
ROSS LAKE
WSR7
LL1
LYNE LAKE
WHITESAND LAKE
Lake Superior
HWY 17
C.P.R.
WSR 1
KENABIC LAKE
SCALE
0
2
4
6 km
WSRI STATION
ZENMAC MINE
MINNOVA-WINSTON LAKE
RESOURCE ACCESS ROAD
GILL NET LOCATION

maximum depth of 65 feet. The distance from the head of Cleaver Lake to the head of Whitesand Lake is approximately 15 km.

- Located approximately 800 m to the southeast of the Winston Lake Mine is the abandoned Zenmac Mine site, which included reactive waste rock piles and an seeping adit (sealed in 1977) on the shore of Kenabic Lake.

- The study, "*Winston Lake Project: Environmental Studies*" found that the Whitesand River watershed was characterized by outcrops of low permeability bedrock and shallow soils. The strongly broken, rolling topography was found to slope from approximately 600 m above sea level (ASL) near the Winston Lake deposit, to 300 m ASL where the access road joins the Trans-Canada Highway. The Lake Superior shoreline was approximately 180 m ASL. The groundwater flow occurred mainly in fractures within the rock mass, and that the water storage capacity of the soils was low. The lake basins were expected to be shallow depressions connected by small inflow and outflow creeks.

- The hydraulic gradient was described as moderate to steep throughout the area. As a result of these factors, lake levels and stream flows showed a marked seasonal variation. The storm flow response is rapid, and flooding commonly occurs during the spring melt and after heavy rainfall events. The small areas of muskeg or marsh have developed along the lake edges or drainage creeks, have a limited capacity to retain water during high flow periods.

4.1.2 Geology/Background Geochemistry

- The Winston project area is located within the Big Duck Lake volcanic that is one of several amoeboid remnants of the Archean Wawa volcanic belt, a liner orogenic feature of the Superior Province populated by numerous volcanic-sedimentary complexes and diapiric granitic bodies of batholithic proportions.

- The volcanics in the Big Duck Lake-Winston Lake area comprise an elliptical, east-west trending, north facing sequence of felsic to mafic metavolcanics that are overlain by metasediments, intruded by gabbroic plutons and bordered to the north, south and west by granitic batholiths. An upper greenschist to lower amphibolite facies regional metamorphic overprint tends to obscure primary lithological features.

- Approximately 30% of the Winston orebody sits on top of chlorite-biotite-anthophyllite-cordierite (altered mafic flow) while the other 70% is in contact with a unit composed of biotite altered "clotted" rhyolite, and bimodal volcaniclastic unit similar to the hanging wall cherty ash but generally banded on a coarser scale. The contacts of the ore are generally very sharp and commonly marked by a 1 to 3 mm chloritic seam. The ore zone varies in thickness from 2 m to +20 m (horizontal) with an average of 7 m.

- There are two main ore types. The first is a massive to locally banded, fine to medium grained homogeneous mix of sphalerite, pyrrhotite, pyrite and chalcopyrite with 10-20% included fragments ranging from <1 cm to 5 cm. This type is considered "low-grade" with values generally in the 7-14% Zn range. The second "high-grade" ore type is predominantly composed of medium to coarse grained sphalerite, massive or locally banded with chalcopyrite and/or pyrrhotite. Grades in this material can be as high as 54% Zn. An overall zonation of ore types is not presently apparent, possibly due to multiple source points.

4.1.3 History

- As described in the "*Metall Mining Corporation Winston Lake Division Closure Plan Volume 1*"(currently under review pending approval), the access road and parts of the Winston Lake minesite were developed for industrial purposes prior to development of the Winston Lake mine. The abandoned underground Zenmac mine supplied zinc ore to an off-site concentrator plant from 1966 to 1970. Previously, the Zenmac mine, which is located approximately 800 m southeast of the Winston Lake mine operated as a surface mine from 1898 to 1902.

- Metall Mining Corporation (then, Corporation Falconbridge Copper) completed initial reconnaissance geological and lithological surveys in 1978. Forty-two claims were staked to the west and north of the Zenmac property and an option agreement was negotiated on the Zenmac property.

- Additional geochemical studies were conducted in 1979 and 1980 that to diamond drilling programs completed in 1981 and 1982. In 1982, the Winston Lake ore body was intersected as 2.1 meters of massive sulphides at a depth of approximately 300 meters.

- Construction of the concentrator, underground development and road upgrading began in 1986. The first ore was processed in the mill in January 1988.

- Original mineable reserves including 20% dilution at zero grade were 3,076,339 tonnes at 1.0% Cu, 15.6% Zn, 30.9 g/t Ag and 1.0 g/t Au. Current mineable reserves as of January 1993, were quoted as 1,550,000 tonnes at 0.97% Cu and 13.08% Zn. Mineable reserves are projected to be depleted by the end of 1996.

- Extensive diamond drilling program was conducted both from the surface and underground in the vicinity of the Winston Lake deposit and the nearby Pick deposit. Detailed underground exploration of the Pick Lake deposit was initiated in 1993.

4.1.4 Milling Methods

- The Winston Lake mill has the capacity of processing 365,000 tonnes per year. The ore grades from 0.8-1.2% copper and 12-18% zinc and consists mainly of sphalerite, chalcopyrite, pyrite and a siliceous gangue. Copper-zinc ore passes through a copper-zinc flotation circuit followed by separate concentrate handling systems to yield separate copper (25.0% Cu) and zinc (54.0% Zn) concentrates.

4.1.5 Effluent

- Solid tailings generally are produced 700 to 750 dry tonnes per day. Following clarification in the tailings impoundment, the supernatant is drawn into the reclaim system for distribution to the mill process, to underground and to the treatment system. Refer to Figure 4.3.

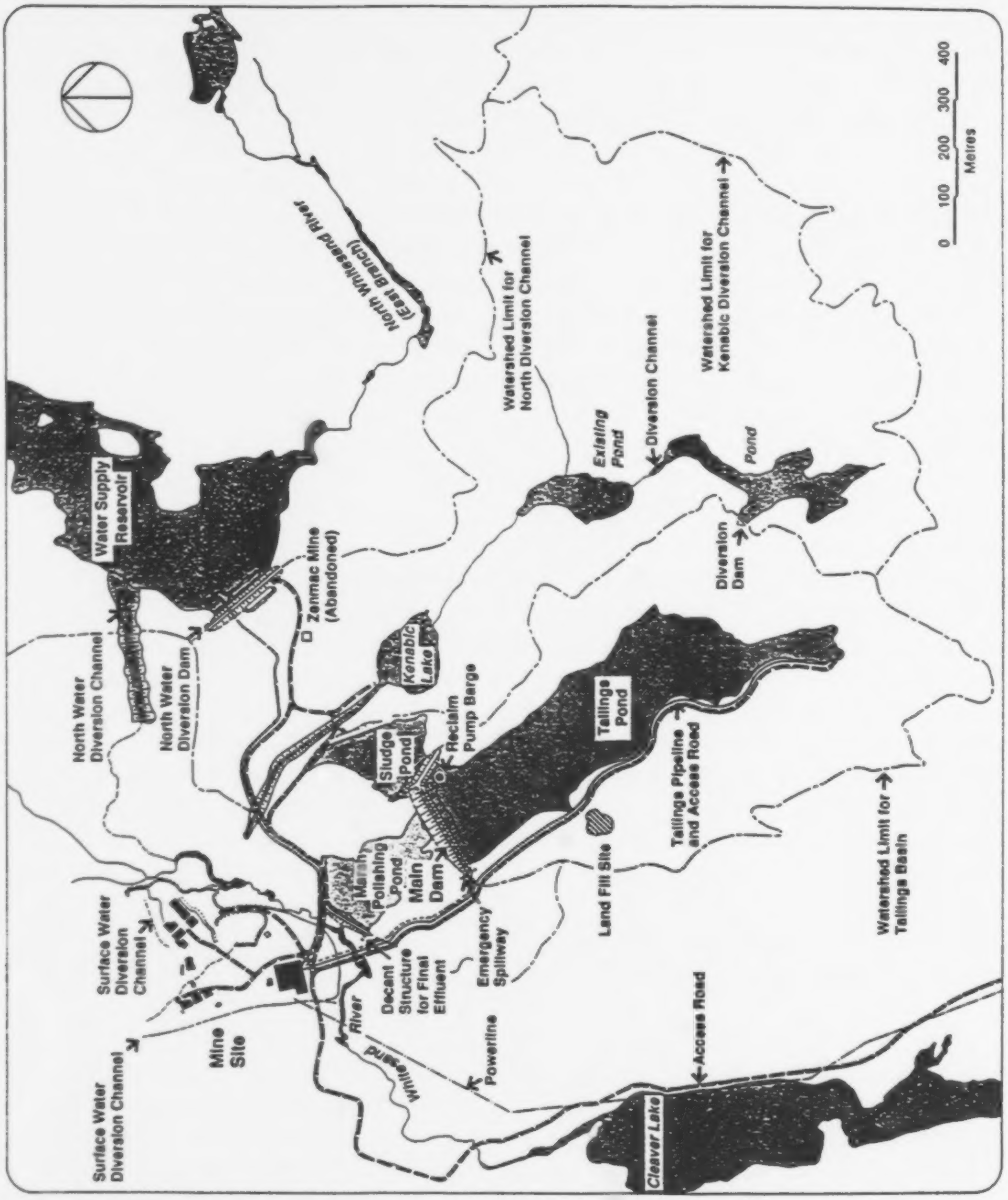
4.1.6 Effluent Treatment

- The tailings impoundment is located to the south of the plant site in a shallow valley (Figure 4.4). At the upstream end of the impoundment, the South Dam and the South Diversion Channel direct runoff from the upper basin into Kenabic Lake. The "*Metall Mining Corporation Winston Lake Division Closure Plan Volume 1*"(currently under review pending approval) cited benefits of this arrangement are the minimization of freshwater runoff into the tailings impoundment and provision of freshwater dilution to Kenabic Lake. This reduces the toxicity input to and improving the water quality of outflow from Kenabic Lake.

- Surface runoff from the plant site (i.e., mill, administration, headframe, etc.) is directed into the site runoff pond. This pond is lined with a 60 mil high density polyethylene (HDPE) liner which minimizes seepage loss. The site runoff pond was designed to contain a 1 in 10 year precipitation event. Water collected in the site runoff pond is returned into the tailing impoundment where it becomes part of the recycle, process and treatment systems.

- Freshwater is used in the mill process for reagent mixing and for potable water. Efforts have been made to minimize the volume of freshwater required since high freshwater

Figure 4.4: Winston Lake tailings area site plan


Water Supply Reservoir
North Whitesand River (East Branch)
Watershed Limit for North Diversion Channel
Watershed Limit for Kenabic Diversion Channel
Existing Pond
Diversion Channel
Pond
Diversion Dam
Zenmac Mine (Abandoned)
Kenabic Lake
North Water Diversion Channel
North Water Diversion Dam
Sludge Pond
Reclaim Pump Barge
Tailings Pond
Tailings Pipeline and Access Road
Watershed Limit for Tailings Basin
Land Fill Site
Marsh Polishing Pond
Main Dam
Emergency Spillway
Decant Structure for Final Effluent
Surface Water Diversion Channel
Surface Water Diversion Channel
Mine Site
Whitesand River
Powerline
Access Road
Cleaver Lake
0 100 200 300 400
Metres

use increases the demand on storage and treatment facilities.

- The water treatment system ensures that any water discharged into the Whitesand River meets the criteria set out in the Winston Lake Certificate of Approval. The treatment system includes lime addition, settlement, neutralization with CO_2 and clarification. Generally, process water is pumped to the settlement pond at a flow rate of up to 200 m^3/hr (typically 100 m^3/hr). Depending on the metal concentrations, this water is limed to increase the pH, whereby the target is 10 to 10.5, and precipitate metal hydroxides.

- Depending on pH and ammonia concentration, CO_2 may be injected into effluent at the outflow of the settlement pond. The injection of CO_2 lowers pH which reduces the unionized portion of ammonia in solution. This is typically required in the winter only. The settlement pond overflows into the polishing pond that provides final clarification before discharge. Final effluent discharges into the Whitesand River through a concrete channel and V-notch weir where flowrate and pH are continuously monitored.

- Report # 739 describes the control water management system employed at the Winston Lake Mine.

4.1.7 Seepages/Runoff

- Detailed seasonal monitoring of the abandoned Zenmac mine area and Kenabic Creek from 1989 to 1993 has shown that the abandoned Zenmac mine yard and shaft area is the main source of zinc in Kenabic Creek. The "*Metall Mining Corporation Winston Lake Division Closure Plan: Volume 1*"(currently under review pending approval) indicates that samples were taken along the ditch that collects surface flow from the abandoned Zenmac mine yard and shaft area; then, directs these flows into Kenabic Creek. Samples were also taken from Kenabic Creek both at the outflow of Kenabic Lake and further downstream from the Certificate of Approval (C of A) station.

4.1.8 Compliance Record

- The "*Metall Mining Corporation Winston Lake Division Closure Plan: Volume 1*"(currently under review pending approval) cites that the overall C of A compliance record from 1988 to October 1933 is 97.5%. Weekly and monthly analyses of discharge effluents are contained in that report.

- The C of A requires periodic toxicity testing of final effluent during periods of discharge. Eight 96-hour tests were performed from 1988 to October 1993. All tests resulted in LC_{50} concentrations >100% (<50% mortality at 100% concentration) and seven of the eight tests were non-lethal (no mortalities) to rainbow trout.

- Trend in concentrations of ammonia at the inflow to Cleaver Lake correlate with periods of Winston Lake discharge. Four exceedances of unionized ammonia were reported in the "*Metall Mining Corporation Winston Lake Division Closure Plan: Volume 1*"(currently under review pending approval). These occurred in November 1988.

- However, the closure plan cites that the trends in copper concentrations at the inflow to Cleaver Lake are due to drainage from the abandoned Zenmac mine area and Kenabic Lake. Trends in combined metals (i.e., copper, lead, nickel and zinc) are similar to trends in concentration of zinc as zinc is the dominant contributor to the calculation of combined metals.

4.1.9 Acid Mine Drainage

- The "*Metall Mining Corporation Winston Lake Division Closure Plan: Volume 1*"(currently under review pending approval) cites that acid base accounting analysis of a pilot plant tailings sample (1986) indicated that Winston Lake tailings were potentially acid generating. Acid base accounting results indicated an acid generation potential (AP) of 445.5 equivalent kg H_2SO_4 per tonne and a neutralization potential (NP) of 83.3 equivalent kg H_2SO_4 per tonne. The net neutralization potential (NP - AP) was -362.2 equivalent kg H_2SO_4 per tonne.

- Following the 1986 test results, subsequent acid base accounting analyses were performed on 8 tailings samples during the period of January 1991 to August 1993. These results were consistent and verified that the tailings were potentially acid generating. The above report also indicated that the net neutralization potential of the tested samples was in the order of -429 tonnes $CaCO_3$ equivalent per 1,000 tonnes.

4.1.10 Physical Disturbance

- Report #738 outlined the environmental impacts relating to the construction of the mine shaft, mill and the service buildings. The physical disturbance as well as environmental impacts were site-specific and related to the use of heavy equipment. Furthermore, the Report stated that: "*The potential for siting of facilities on a swampy area to the east of the shaft would result in the loss of an area of wetland which exerts a modifying effect on local hydrology and water chemistry. As much of this area as is feasible should be retained as a buffer against flooding and water contamination.*"

4.2 Description of Quality and Quantity of Information for the Mine Site

4.2.1 Study/Experimental Design Adequate

- A condition as cited by the report "*Impact of the Zenmac Mine on the Whitesand River Water Quality*" in the Ontario Ministry of the Environment Certificate of Approval (C of A) required the Minnova Inc. Winston Lake Division to study the relative impact of the abandoned Zenmac Mine on the Whitesand River and propose remedial actions

- The Winston Lake C of A identifies 4 monthly surface water sampling stations. These are the freshwater reservoir, Kenabic Creek, inflow to Cleaver Lake and inflow to Lyne Lake. The C of A requires weekly sampling of polishing pond final effluent during periods of discharge.

- The C of A specifies maximum allowable concentrations of metals and other potential contaminants in final effluent. An exceedance is considered to occur when the average of 4 consecutive analyses is above the maximum allowable concentration. Mine discharges have a compliance record with C of A guidelines of 97.5% to October 1993.

- As required by the Ontario Ministry of the Environment and Energy, as part of the MISA obligation, quality control and quality assurance (QA/QC) data are obtained annually as a condition of the C of A since 1988. Winston Lake Mining Division reports this information as part of their annual performance report.

- As part of the validation process of QA/QC methodologies, Winston Lake participated in the third Noranda Interlaboratory Working Group Round Robin held in mid-1990. The testing included analyzing six samples for copper, lead, zinc and cadmium. A total of 23 laboratories participated in this study.

- During the first half of 1991, Minnova participated in the Proficiency Environmental Testing Program to evaluate the laboratory performance of Thunder Bay Analytical against other participating labs. The program was administered by Analytical Products Group of Belpre, Ohio.

4.3 Results of Aquatic Effects Assessment

4.3.1 Water Quality

- As described in Report #740, the Whitesand River begins approximately 4 km upstream of the Winston Lake Mine site, draining approximately 7.5 km^2 , and continues for approximately 20 km, draining a total of 135.3 km^2. Immediately below the confluence of Kenabic Creek with the Whitesand River, the flow was measured at 0.226 m^{-3} in October 1983. Below the mine site it passes through 11 lakes and Rainbow Falls Provincial Park, before emptying into Lake Superior. (See Figure 4.3)

- Report #740 cites that the original Zenith mine extracted 3,800 tons of 45% zinc ore, the abandoned flooded Zenmac Mine extracted 181,830 tons of 16.5% zinc ore. The flooded Zenmac mine and the waste rock piles from both previous mines were the main sources of metal contamination for the Whitesand River as indicated in Report #738. Seepage from these sources enters Kenabic Lake and Kenabic Creek. Both these surface waters show elevated metal levels, particularly zinc. This contamination results in a decreasing zinc concentration gradient in surface water and sediments, downstream of the mine site.

- Report #740 further indicated that mine processes result in waste water from the concentrator, mine drainage, and domestic sewage, as well as tailings solids, to be discharged into the upstream end of the tailings pond. Following a retention time of one year, the decant water is drawn off for recycling in the concentrator and mine processes. Recycled water accounts for 96% of all water used in the concentrator. Excess decant water is mixed with lime to keep the pH above 9.5, held in a settling pond, and then is allowed to pass through a polishing marsh planted with emergent aquatic plants and then discharged into the Whitesand River. Carbon dioxide is added as required, to modify the effluent pH, thus, lowering the concentration of unionized ammonia.

- Reports #740 showed that the major contaminant, zinc is typically 0.25 mg/L (C of A max 0.50 mg/L Zn) in the effluent discharged into the Whitesand River. This is less than the Ontario Drinking Water Objectives (1983) whereby the recommended level is 5 mg/L; but is higher than the Provincial Water Quality Objectives (1984) of 0.03 mg/L for surface water.

- From the grab water samples taken for analysis in Report #740, all metals then analyzed exceeded the Ontario Ministry of the Environment (MOE) (1984) Guidelines or the Canadian Water Quality Guidelines (1991) for surface water, at least at one location usually near the source of the mine effluent and Kenabic Creek, which receives run off from the abandoned Zenmac mine site.

- Furthermore, Report #740 concluded that seepage from the abandoned Zenmac Mine continues to be a major source of metal contamination downstream, especially Zn. This is verified by the negative response of the benthic communities to Zn and Cu concentrations in the river.

- It also stated that the rehabilitative work underway since 1989 on the Zenmac mine site by Minnova Inc., has resulted in reduced metal levels in the Whitesand River. Water chemistry and benthic invertebrate communities reflect this improvement in water quality.

- However, the lime treatment of the effluent from the Winston Lake Mine by Minnova Inc has resulted in the accumulation of calcium in the hypolimnion of Cleaver Lake. Hence, a chemocline has formed rendering the hypolimnion resistant to mixing; causing anoxia in the hypolimnion and impacting the biotic community of Cleaver Lake.

- Report #739 also indicates that the abandoned Zenmac Mine was the source of poor quality water in the Whitesand River. This included trends of decreasing concentrations of most parameters with distance downstream from the confluence with Kenabic Creek.

- Report #739 outlines water quality improvements resulting from progressive reclamation of the abandoned Zenmac mine site during operation of the Winston Lake Mine in conjunction with the water diversion works constructed during development of the Winston Lake mine has resulted in significant improvements in the water quality in Kenabic Lake and Kenabic Creek. These results have contributed to the improvements of the toxicity in Cleaver Lake.

4.3.2 Sediment Quality

- Of the four studies containing sediment surveys, three of the studies were conducted before Winston Lake commenced operation in 1987.

- The MOEE 1983 study was a preliminary survey where two sediment core samples were taken in Kenabic Lake and Kenabic Creek. The core samples were subdivided into 2 cm sections and submitted for metal analyses. Sediment core chemistry results revealed elevated concentrations of iron, aluminium, cadmium, arsenic, copper, mercury cobalt and zinc. Of greatest concern was the extensive layering of zinc, copper, cadmium and arsenic in the upper horizons of Kenabic Lake and Creek.

- Report # 738 cites the Beak Consultants' study of the sediment quality at sites along the Whitesand River. Samples were taken from Hornblende Lake, Cleaver Lake, North Cleaver Lake, Kenabic Lake, North Whitesand Lake and Winston Lake. Provincial sediment quality objectives were exceeded for Zn, Cr and Cu at all the sites sampled. Cadmium exceeded objectives at all except North Cleaver and Winston Lake. Lead exceeded the objectives in Hornblende Lake and Kenabic Lake. Zinc levels were of most concern because they were found to be high as far down as Hornblende Lake.

- In 1987, Noranda Research collected and analyzed sediments from Cleaver, Gumboot, Hornblende and Lyne Lakes. Again, copper, zinc, lead, cadmium levels were elevated at some or all locations and exceeded the lowest effect levels stated in the Provincial Sediment Quality Guidelines (1992).

- Report # 740, BAR Environmental conducted a study after Winston Lake had been operating for five years and after clean-up measures were undertaken at the abandoned Zenmac mine site to reduce leaching of metals into the Whitesand River. Flows were diverted around the waste rock piles and all of the waste rock piles were removed to a safe disposal area. Sediment samples were taken from stations used in the 1987 study on the river system.

- Besides the 7 river sites used in 1987 by Wood (1988), an additional site at Kenabic Creek as well as a control station immediately upstream of the contaminant input, were added to better define the nature of the impact. Three sites were also sampled in Cleaver Lake, the first lake downstream of the mine site. Multiple core samples were taken at all Cleaver Lake stations, using a KB Corer with clean plastic inserts. At river stations, one grab sample was collected at each station where possible. A sediment sample from the freshwater reservoir additional to the established Whitesand River stations was included to further characterize the sediments upstream of the mine site.

- All parameters were compared with the Provincial Sediment Quality Guidelines (1992). Contaminants within the river sediments displayed few discernable trends likely due to the constant mixing and grading of sediments in high gradient streams. Only copper and zinc appeared to track one another and were generally elevated relative to levels found in sediments from the control station or freshwater reservoir.

4.3.3 Benthic Macroinvertebrates

- Seven reports spanning a time period from 1983 to 1994 were reviewed. Three of these studies were conducted before Winston Lake Mine became operational and hence provided useful base line information on the state of the benthic community in the Whitesand River.

- The MOEE 1983 study was preliminary and aimed at identifying pre-operational conditions in the Whitesand River system. Benthic samples were collected in on June 13 and 14 in Kenabic Lake and at four locations on the Whitesand River. Lake stations were sampled with a Ponar grab (5/site) and river stations by Surber sampling (2/site) and qualitative sieve sampling (2/site). Habitat information was noted and descriptions of substrate, flow and vegetation at the different sites were given. No control location was sampled.

- Report # 738, Beak Consultants' study conducted for Corporation Falconbridge the Fall of 1983, sampled three stream sections of the Whitesand River using a Surber sampling technique with two samples at each site. Beak like MOEE did not sample a control location.

- In June 1987, the most comprehensive of the pre-operational studies was conducted by Noranda Research Centre for Minnova Inc. where seven stations with similar substrate along the Whitesand River were sampled by Surber stream bottom sampling (six samples pooled to from one sample at each site). No control site was sampled.

- The MOEE study and Beak study did not include any treatment of the data or any detail of standard operating procedures. The data was presented as the different genera and numbers of organisms collected per sample per site. There was discussion of the relationship between the benthic community present at sites and metal concentrations of the water.

- The June 1987 study included all standard operating procedures used for sample collection and handling. The benthic organisms were classified down to genera and results were treated using a computer based diversity index which calculated the diversity index for the communities sampled at each station relative to the abundance and diversity of organisms found at each site. There was also a classification of organisms into groups of sensitive, intermediate and tolerant organisms. Of the three baseline studies the 1987 study appeared to be the most reliable one from which to draw conclusions, and served to confirm some of the findings of the earlier studies. The site map (Figure 4.3) clearly illustrates the sampling locations relative to the old Zenmac mine and the proposed Winston Lake operation.

- Report # 740, the most recent benthic survey and the only one available that was conducted after the Winston Lake Mine began operation was done after clean-up measures were undertaken at the abandoned mine site to reduce leaching of metals into the Whitesand River. Unfortunately, the sampling was done in October and so it immediately introduces seasonal limitations into the comparison with the baseline studies two of which were done in June. In addition to sampling the 7 sites sampled in 1987, a control site upstream of the contaminant input was surveyed and also a site at Kenabic Creek. Three sites were also sampled in Cleaver Lake, the first lake downstream of the mine site. River stations were sampled by Surber (6 surber collections per sample and 3 samples per site) while in Cleaver Lake samples were collected with an Ekman sampler (6 Ekmans per sample and 3 samples per station)

- All standard operating procedures including subsampling and calculation of sub-sampling error were provided.

- A variety of standard indices were calculated to evaluate the state of the benthic community. Full statistical analyses were done to identify spatial trends in the data and correlate benthic abundance water and sediment quality parameters. Cluster analysis and multidimensional scaling were conducted with the logE transformation of the abundance data.

- Stations 3-7 which were downstream of Cleaver Lake were similar to the control in terms of number of taxa and two of the indices calculated. Benthic invertebrates were particularly scarce at two of the sites in Cleaver Lake. The cluster analysis showed that the most dissimilar clusters are sites close to the contaminant sources on one hand and those more distant from contaminant sources on the other hand. This clearly shows a relationship between the benthic community present and the contaminants. The multidimensional scaling analysis illustrates this same pattern when related to zinc water levels at each station. The multidimensional scaling analysis suggests that zinc and copper concentrations in the water and the sediment are likely influences on the benthic community composition in the Whitesand River.

- When the 1992 data is compared to the 1987 data, there appears to be a decrease in 1991 in the total number of taxa detected at the first three stations relative to the number detected in 1987. At all other sites, further downstream there is an increase in 1991 in the total number of taxa. The small differences observed could be due to seasonal variation but only since the 1992 study was done in October while the 1987 work was conducted in June. In 1991, all river stations exhibited an increase in the number of Ephemeroptera present. This may be a good indication of improved water quality.

4.3.4 Fisheries

- Pre-operational, i.e., prior to 1966, fisheries data for the abandoned Zenmac Mine are not available.

- In October 1983, gill netting efforts were conducted as part of a pre-operational baseline study for the Winston Lake Mine.

    1) Fish could not be captured after 72 hours of gill netting in Kenabic Lake, which had been contaminated by previous mining operations conducted from 1898 to 1890 and, as the Zenmac Mine, from 1966 to 1970.

2) Concentrations of Cu, Zn, Cd, Al and Pb in Kenabic Lake water were **20, 137, 500, 38 and 80 times** their respective Water Quality Guidelines for the protection of freshwater aquatic life.

3) A total of only seven fish were collected from three other lakes in the area; 3 brook trout from Cleaver lake, 1 brook trout from Hornblende Lake, 2 brook trout and 1 creek chub from Winston Lake.

4) Concentrations of Al, Cd, Co, Cr, Cu, Fe, Ni, Pb, Sr, Ti, and Zn in the flesh of those six brook trout were well below those considered harmful for human consumers of fish.

5) No measurements were made on the adverse effects of metals on the health of resident fish.

- In the summer of 1987, a second pre-operational survey of fish was conducted.

1) Concentrations of As, Cd, Pb and Hg in flesh of 32 brook trout from Cleaver Lake; of 9 brook trout and 3 lake trout from Lyne Lake; and of 2 brook trout, 24 lake trout, 20 smallmouth bass, and 20 lake whitefish from Whitesand Lake were obtained. Fish were collected from June to August, 1987; and data are provided on their length, weight and sex.

The contaminant data indicate that concentrations of As, Cd and Pb are well below those considered harmful for human consumption; and that "Hg levels found in the Whitesand River watershed are generally typical of the Hg levels in fish found in lakes north of Lake Superior." No gradients due to discharge of mining effluents in metal contamination of fish flesh were observed.

2) Other fish species were collected from Lyne Lake, but were not analyzed for metals. These species were longnose sucker (*Catastomus catastomus*), white sucker (*Catastomus commersoni*), blacknose dace (*Rhinichthys atratulus*) and cisco (*Coregonus artedii*).

- Only one brook trout was captured in Cleaver Lake in October 1991, using four 1-hour sets of 300 feet of gill net of 38 mm stretched mesh.

1) A six-foot trap net was set in several "good brook trout foraging habitat" sites over 5 days in May 1992, and only 2 brook trout (a 4-year old and a 6-year old) were caught.

2) Four stations on the Whitesand River, ranging from the head of Cleaver Lake to the head of Lyne Lake and selected as "being ideal brook trout habitat", were electrofished during May, 1992. These were found to "contain very few fish". Only two brook trout, four pearl dace, one longnose dace and one trout perch were captured.

3) In the Discussion of Report #740 describing this work, the authors state that brook trout were more abundant in 1987 than they were in 1992, and that "it is unclear why the Whitesand River system has such a low density of fish" in 1992. They downplay the role of contaminants, for example by stating "Zn and Cu levels downstream of Cleaver Lake are **probably** reduced sufficiently to be non-toxic to brook trout."
4) Toxicity testing data (refer to **Toxicity Testing** section below), however, contradict this statement on non-toxicity because the water from Cleaver Lake was lethal to rainbow trout and *Daphnia.* Chronic sub-lethal effects on the health of resident fish were not measured.

- Analyses of water samples collected from Cleaver Lake in June, August and October 1993 documents a chemocline which had developed in Cleaver Lake due to the discharge of dense lime-treated final effluent from the Winston Lake mining operation.

  1) the hypolimnion was characterized by anoxia and high concentrations of ammonia, calcium, sulfate, iron and copper.

  2) No hypolimnic data were presented for other metals, such as zinc, cadmium, lead and nickel.

  3) Concludes that these conditions force "brook trout in habitat conditions typically believed to be beyond the fish's physiological maxima for survival", especially with regard to temperature and dissolved oxygen conditions during late summer.

  4) Raised the question as to whether the resident brook trout can survive, and makes the point that brook trout populations were self-sustaining up to at least 1992.

- No brook trout could be captured from Cleaver Lake in June 1994 by MNR staff conducting a fish survey using index netting.

  1) Several options are discussed for restoring Cleaver Lake, but the authors conclude that "the preferred option for restoration of Cleaver Lake is to let the lake recover naturally."

2) It is very difficult to concur with this recommendation because the strong chemocline renders the hypolimnion resistant to mixing, and, therefore, the hypolimnion stays anoxic with high concentrations of ammonia and metals. [The Company's view: The recommended option provides the best protection for downstream lakes over the short term; Cleaver Lake will recover naturally after mine closure.]

- The report entitled "*Metall Mining Corporation, Winston Lake Division Closure Plan: Volume 1*",(currently under review pending approval) information on fish surveys described in previous reports is briefly reviewed, and the point that contaminant levels in fish do not exceed consumption advisories is emphasized.

1) No remarks are made on the effects of these contaminants on the health of resident fish.

2) The report refers to two appendices that were not included; these are:
   a. Appendix 3: "Fish Survey Details, 1983 to 1992", and
   b. Appendix 7 "Toxicity Test Results, 1987 to 1993".

4.3.5 Toxicity Testing

- Water was collected from Kenabic Creek and Cleaver Lake in October 1991, and was tested for toxicity in a Guelph, Ontario laboratory. The toxicity of metals would be less in the dilution water used for these tests at the Guelph lab, because it was extremely hard water (260 mg/L as $CaCO_3$)

1) Tests used were the 96 hour, static, acute LC_{50} bioassay with rainbow trout; the 48 hour, static, acute LC_{50} bioassay with *Daphnia magna*; and the Microtox™ EC_{50} bacterial bioassay.

   a. With exposures of Kenabic Creek water to these species, the order of increasing sensitivity was bacteria (least sensitive) < trout < *Daphnia* (most sensitive).

   b. Cleaver Lake water was less toxic to trout, *Daphnia*, and bacteria than Kenabic Creek water. LC_{50} values (expressed as percentage of water from the two sources) were about two times higher for trout (64% vs 25%) and *Daphnia* (33% vs 18%) exposed to Cleaver Lake water as compared to exposures to Kenabic Creek water. The 15 min EC_{50} for bacteria exposed to Kenabic Creek water was 38%, whereas toxicity was not detected (15 min

$EC_{50} > 99\%$) with Cleaver Lake water.

c. Zinc concentrations in Kenabic Creek water exceeded published LC_{50} values by a factor of approximately 10 times, and the concentration of zinc in Cleaver Lake exceeded these values by a factor of 1.5.

2) The authors state that other metals, including copper, in Kenabic Creek water also exceeded PWQO's. Data should also have been obtained for Cd, Al, and Pb, because they were far above their WQG's in 1983 (Refer to Fisheries section).

- In Report # 739, claims are made that improvements due to water diversion to water quality to Kenabic Lake and Kenabic Creek have contributed to improvements to the toxicity of Cleaver Lake water. The following examples are given without any details on data, time of year or methodologies:

1) Zinc concentrations in Kenabic Creek decreased "from an annual average around 8 mg/L in 1987 and 1988 to around 2.5 mg/L in 1993."

2) "In Cleaver Lake, LC_{50} toxicity test results for rainbow trout improved from 18% and 26% in 1987 and 1988 to 64% in 1991."

3) The point remains that Cleaver Lake water tested in 1991 was still lethal to rainbow trout due to the continuing effects of drainage from the abandoned Zenmac mine.

4.4 Discussion

4.4.1 Evidence for Aquatic Effects

4.4.1.1 Effects on Use of Water

- Report #740 concluded that seepage from the abandoned Zenmac Mine continues to be a major source of metal contamination downstream, especially Zn. This is verified by the negative response of the benthic communities to Zn and Cu concentrations in the river. The rehabilitative work underway since 1989 on the Zenmac mine site by Minnova Inc., has resulted in reduced metal levels in the Whitesand River. Water chemistry and benthic invertebrate communities reflect this improvement in water quality.

- Report #740 showed that the major contaminant, zinc is typically 0.25 mg/L in the effluent discharged into the Whitesand River. This is less than the Ontario Drinking

Water Objectives (1983) whereby the recommended level is 5 mg/L but is higher than the Provincial Water Quality Objectives (1984) of 0.03 mg/L for surface water.

- The one impact observed in Report #740 that was due to the current Winston Lake Mine operations is the formation of a calcium/sulphate chemocline in Cleaver Lake. The chemocline has resulted from the discharge of lime treated mine effluent to Cleaver Lake from the Winston Lake Mine. The chemocline has rendered the lake resistant to mixing and this results in anoxia in the hypolimnion.

4.4.1.2 Effects on the Benthic Environment

- All the baseline studies concluded from the benthic data that the majority of the benthic populations in the Whitesand River were composed of pollution tolerant and /or intermediate tolerant organisms. The MOEE (1983) study noted a relationship between metal concentrations in the water. The numbers of taxa increased as the levels of cadmium and zinc decreased. Reduced numbers of taxa and low densities of organisms were found at the upstream stations.

- Beak (1984) observed a clear toxic effect of what was believed to be high zinc concentrations on the benthic community which extended as far downstream as Cleaver Lake.

- All the baseline studies indicated that there were significant effects on the Whitesand River benthic populations resulting from the former release of mine and mill process wastes as well as existing seepage from the old Zenmac Mine site.

- From the 1992 study and based on comparisons with previous studies, the benthic community reflects that the rehabilitative work carried out on the Zenmac Mine site has improved the water quality of the Whitesand River at least at the river stations sampled. Seepage from the abandoned mine is still however a major source of metal contamination especially of zinc. The benthic communities show a clear negative response to zinc and copper concentrations in the water and further monitoring should definitely include comprehensive benthic surveys.

- The one impact observed by BAR(1992) that was clearly due to the current Winston Lake Mine operations is the formation of a calcium/sulphate chemocline in Cleaver Lake. The chemocline may be responsible for the paucity of the benthic fauna collected in Cleaver Lake in 1992.

4.4.1.3 Effects on Fish

- Fishing surveys in 1987 and 1992 indicate that brook trout were much more abundant in Cleaver Lake and the rest of Whitesand River prior to the beginning of operation of the Winston Lake Mine than after operation.

- Two major factors, the severe chemocline which has developed in Cleaver Lake since the onset of Winston Lake Mine operations and the acute lethality produced over several years by Cleaver Lake water to rainbow trout and *Daphnia*, reflect the most likely parameters responsible for the capture of very few fish in the Whitesand River watershed in recent years. Those parameters include high concentrations of zinc, copper, cadmium, aluminum, lead and ammonia; along with low concentrations of hypolimnetic oxygen.

- Data on metal concentrations in fish are restricted to flesh only. Concentrations exceeding guidelines for the human consumption of fish were never reported with the exception of mercury. Mercury concentrations, however, were considered typical of those found in lakes north of Lake Superior.

4.4.2 Effectiveness of the MMLER and Provincial Regulatory System

- Adequate data are not presented for assessing the effectiveness of federal and provincial regulations for protecting the health of resident fish stocks and of human consumers of those fish.

- The MISA Mining Regulation Limits for Zn, As, Ni, Pb, and Cu are considerably higher than the Water Quality Guidelines for the protection of freshwater aquatic life.

4.4.3 Assessment of Monitoring Program Adequacy

- The sediment studies were well designed except for lack of a control site in the baseline surveys. However, based on the standard operating procedures, quality control measures taken and the fact that multiple studies were done, the baseline study results can still be considered as reliable data on which to base future work. There is need for continuing sediment studies to monitor changing metal levels in the Whitesand River system. The sediment monitoring will enable assessment of the effects of clean-up measures being implemented at the old Zenmac mines and any changes in the processes carried out at the operating Winston Lake mine.

- Although the baseline studies lack statistical data analysis and multiple samples, the similar findings of the three studies strengthen the conclusions. Modifications recommended for the baseline study designs are the use of a control site to establish background conditions for the area more samples per site and statistical analysis to show relationships between the benthic community and sediment/water quality parameters. The 1992 post-operational study was well designed with two control sites and multiple samples per site. However, the study was conducted in October and not in June like the baseline studies. Future studies should be conducted both in June and October to capture seasonal variation.

- Two major factors, the severe chemocline which has developed in Cleaver Lake since the onset of Winston Lake Mine operations and the acute lethality produced over several years by Cleaver Lake water to rainbow trout and *Daphnia*, reflect the most likely parameters responsible for the capture of very few fish in the Whitesand River watershed in recent years. Those parameters include high concentrations of zinc, copper, cadmium, aluminum, lead and ammonia; along with low concentrations of hypolimnetic oxygen.

- Chronic sub-lethal effects of contaminants discharged by mining operations on the health of resident fish were never evaluated.

- There is need for continued monitoring of the Whitesand River to assess the impacts of past and present mining activities on the aquatic communities. Remedial measures should be applied where necessary to preserve this highly sensitive river system.

4.5 References

B.A.R. Environmental Inc. (1992) *Biological Monitoring of the Whitesand River*, July 1992, report prepared for Minnova Inc., (AQUAMIN Report No. 740).

Hood, C. (1988) *Baseline Aquatic Biomonitoring Program for Minnova Inc., Winston Lake Project June 1987*, report prepared for Corporation Falconbridge Copper Ltd by Centre de Recherche Noranda

IEC Beak Consultants Ltd. (1984) *Winston Lake Project: Environmental Studies*, October 1984, Consultant report prepared for Corporation Falconbridge Copper, Thunder Bay, Ontario (AQUAMIN Report No. 738).

Laine, A.O. (1994) *Upstream Mining Impacts on Cleaver Lake Water Quality, 1993,* Ontario Ministry of Environment and Energy, January 1994, (AQUAMIN Report No. 161).

Metall Mining Corporation (1993) *Metall Mining Corporation, Winston Lake Division Closure Plan, Volume 1: Text, Figures and Tables*, report prepared for the Ontario Ministry of Northern Development and Mines.

Metall Mining Corporation and Senes Consultants Ltd. (1994) *Cleaver Lake Restoration Plan (Draft),* July 1994, (AQUAMIN Report No. 739).

Minnova Inc. (1989) *Impact of the Zenmac Mine on the Whitesand River Water Quality,* Winston Lake Division report prepared for Ontario Ministry of Environment, December 1989.

Ontario Ministry of the Environment (1985) *A preliminary water quality evaluation of the Whitesand River (Northshore Lake Superior)*,1983.

Ontario Ministry of the Environment (1992) *Guidelines For The Protection And Management of Aquatic Sediment Quality In Ontario.*

Appendix 1:

Certificates of Approval for David Bell Mine and Williams Mine

Ministry of the Environment
Ministère de l'Environnement
Ontario

CERTIFICATE OF APPROVAL
INDUSTRIAL SEWAGE
NUMBER 4-0075-92-006
Page 1 of 13

TO:

Teck-Corona Operating Corporation
David Bell Mine
P.O. Bag 11
Marathon, Ontario
POT 2E0

Williams Operating Corporation
Williams Mine
P.O. Bag 500
Marathon, Ontario
POT 2E0

has applied in accordance with Section 53 of the Ontario Water Resources Act for approval of:

the establishment of sewage works for the collection, transmission, treatment and disposal of liquid and solid mine and mill tailings from the 6,000 tonnes per day Williams Mine and the 1500 tonnes per day David Bell Mine mine/mill operations in Bomby Township, District of Thunder Bay, consisting of the following:

- one (1) tailings disposal basin located in the Molson Lake basin encompassing 344 hectares, contained on the south-west corner by Dam A, constructed with a compacted till core of permeability not greater than 1 X 10^{-6} centimetres per second to an ultimate elevation of 343 metres above reference datum, and contained on the north by Dams D, E and F, each constructed with a compacted till core of permeability not greater than 1 X 10^{-6} centimetres per second to an ultimate elevation of 347 metres above reference datum, with permeable separator Dam B, in the middle of the basin to an ultimate elevation of 336.0 metres above reference datum;

- three (3) interceptor dykes and seepage collection sumps, with one (1) dyke and one (1) sump located downstream of each of dams D, E, and F, in accordance with drawings entitled Seepage Pathways and Water Quality Monitoring Locations: North Rim Dams, and Schematic Cross-Section, Interceptor Dyke and Collection Sump, North Rim Dams, prepared by Golder Associates, with each sump having a capacity of at least 41,000 L, and each dyke constructed of compacted glacial till to a height of 2 metres, at a slope of 2 horizontal to 1 vertical, complete with a 800 millimetre diameter pipe, and a gated weir,

- at least one (1) portable diesel pump, having a capacity of at least 30 Litres per second, for discharging runoff contaminated with seepage collected in the above mentioned sump to the tailings disposal basin,

- one (1) tailings pond effluent treatment plant with a maximum design capacity of 4,273 cubic metres per day, located at the David Bell Mill, containing a metal precipitation stage utilizing precipitation with ferric sulphate and a lime addition stage (complete with automatic pH control), each stage consisting of one (1) mechanically agitated baffled reaction tank with a capacity of 45.5 cubic metres, a 9.75 metres diameter reactor-clarifier and reagent addition equipment for the addition of ferric sulphate, lime and polymer flocculant, with effluent discharge to Lim Lake;

- one (1) tailings pond effluent treatment plant with a maximum design capacity of 14,400 cubic metres per day, located at the south end of the tailings disposal pond, containing a hydrogen peroxide/copper sulphate treatment process for cyanide destruction and a metal precipitation stage utilizing ferric sulphate, consisting of four (4) mechanically agitated baffled reaction tanks each with a capacity of 200 cubic metres, a 25 metres diameter reactor-clarifier and reagent addition equipment for the addition of ferric sulphate, lime and polymer flocculant, with effluent discharge to Frank Lake;

- all other controls, electrical equipment, instruments, piping, pumps, valves and appurtenances essential for the proper operation of the aforementioned sewage works;

all in accordance with the documents listed in schedule 'A'.

You are hereby notified that this approval is issued to you subject to the following terms and conditions outlined below:

TERMS AND CONDITIONS

1. DEFINITIONS

For the purpose of this Certificate of Approval:

(1) "certificate" means the entire within certificate of approval issued in accordance with section 53, *Ontario Water Resources Act*, and includes its schedules, if any;

(2) "Director" means any Ministry employee within the Environmental Planning and Prevention Division of the Ministry appointed by the Minister pursuant to section 4 of the *Ontario Water Resources Act* as a Director for the purposes of Sections 7, 53, 54, 55 and 56 of said Act;

(3) "District Officer" means the District Officer of the Thunder Bay District Office of the Northwestern Region of the Ministry;

(4) "Ministry" means the Ontario Ministry of the Environment;

(5) "owners" means Teck-Corona Operating Corporation and Williams Operating Corporation and includes each of their successors and assignees;

(6) "Regional Director" means the Regional Director of the Northwestern Region of the Ministry;

(7) "works" means the facility described in the owners' application, this certificate and in the supporting documentation referred to herein, to the extent approved by this certificate;

2. SCOPE OF APPROVAL GRANTED

(1) The approval granted by this certificate is based upon a review of the proposed works in the context of its effect on the environment, its process performance and principles of sanitary and chemical engineering.

(2) The review did not include a consideration of the architectural, mechanical, structural, electrical or instrumentational components of the works except to the extent necessary to review the works as set out in subsection (1).

3. REQUIREMENTS

The requirements of this certificate are imposed pursuant to section 53 of the *Ontario Water Resources Act*. The issuance of this certificate in no way abrogates the owners' legal obligations to take all reasonable steps to avoid violating other applicable provisions of this legislation and other legislation and regulations.

4. INTERPRETATION (Severability and Conflicts)

(1) The requirements of this certificate are severable. If any requirement of this certificate, or the application of any requirement of this certificate to any circumstance, is held invalid, the application of such requirement to other circumstances and the remainder of this certificate shall not be affected thereby.

(2) In all matters requiring the interpretation and implementation of this certificate, the conditions of the certificate shall take precedence, followed in descending order by the owner's application and the documentation, referred to in this certificate, which is submitted in support of the application.

5. FREEDOM OF INFORMATION

(1) In accordance with section 13 of the *Ontario Water Resources Act* this certificate, the application filed to obtain it and certain of the documentation referred to in this certificate which may be reasonably necessary for a proper reading and understanding of it may be made available for public inspection at the request of any person.

(2) Additional information to that set out in subsection (1) relating to this certificate and contained in Ministry files may be made available to the public in accordance with the provisions of the *Freedom of Information and Protection of Privacy Act*.

6. OPERATION

(1) The owners shall not operate the Williams Mine effluent treatment plant beyond the period commencing April 1st and terminating November 15th of each year, unless otherwise approved by the Regional Director in writing.

(2) The owners shall discontinue discharge of treated effluent from a treatment plant to Lim Lake or Frank Lake if any of the requirements of Condition 7 are exceeded and shall not resume discharge until tests have been repeated and successfully demonstrated to achieve the requirements.

(3) The owners shall not operate the effluent treatment plants beyond their approved maximum design capacities.

7. EFFLUENT REQUIREMENTS

(1) The owners shall design, construct and operate the works such that the concentrations of the materials named below as effluent parameters are not exceeded in the effluent from the works being discharged into Lim Lake and Frank Lake, calculated in accordance with subsection (2).

EFFLUENT PARAMETER	EFFLUENT CONCENTRATION (milligrams per litre)
Total Suspended Solids	15
Any Individual Metal (excluding calcium, magnesium, potassium, sodium, copper, lead, nickel and zinc)	1.0
Total Cyanide	2.0
Total Ammonia (Ammonia plus Ammonium)	20.0
Arsenic	0.5
Copper	0.3
Lead	0.2
Nickel	0.5
Zinc	0.5

(2) For the purposes of determining compliance with and enforcing subsection (1), exceedence of a concentration is deemed to have occurred when the arithmetic mean concentration of at least four (4) consecutive samples analyzed for a parameter named in subsection (1) is greater than the corresponding concentration set out in subsection (1).

(3) The Owner shall maintain the pH of the effluent being discharged from the works to Lim Lake and Frank Lake within the range of 5.5 to 10.6, inclusive, at all times. An exceedence of pH is deemed to have occurred when any single measurement is outside of this range.

(4) The effluent being discharged to Lim Lake and Frank Lake shall not be acutely toxic. Non-compliance with respect to toxicity is deemed to have occurred if undiluted effluent fails the 96 hour LC_{50} toxicity test, as described in Condition 8.

8. EFFLUENT QUALITY MONITORING

The owner shall establish and carry out, upon commencement of operations of the works, the following effluent monitoring program:

(1) The effluent streams named below shall be sampled, by grab sampling, in accordance with the measurement frequency specified for each parameter named below, unless otherwise required in writing by this certificate or by the District Officer:

EFFLUENT STREAM	FREQUENCY	PARAMETERS
Williams Mine Waste Stock Pile Runoff	Monthly	Level 1 and 2
Sedimentation Ponds	Monthly	Level 1 and 2
Williams Mine Polishing Pond Discharge	3 Times per Week Weekly	Level 1 Level 2
Treated Effluents (both Treatment plants)	3 Times per Week Weekly Monthly	Level 1 Level 2 Level 3

Level 1 - pH, copper, lead, molybdenum, nickel, zinc, total cyanide.

Level 2 - ammonia, antimony, arsenic, iron, mercury, weak acid dissociable cyanide, alkalinity, conductivity, sulphate and suspended solids.

Level 3 - 96 hour LC_{50}

(2) The methods and protocols for sampling, analysis, toxicity testing, and recording shall conform, in order of precedence, to the methods and protocols specified in the following:

(a) the Ministry's publication "Protocol for the Sampling and Analysis of Industrial/Municipal Wastewater" (October 1991), ISBN 0-7729-8970-2, as amended from time to time by more recently published editions;

(b) the publication "Standard Methods for the Examination of Water and Wastewater" (17th edition) as amended from time to time by more recently published editions; and,

(c) the Environment Canada publications "Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout" (July 1990); C. Different from MISA requirement
aerate sample ½ hour before fish exposure

(d) in respect of any parameters not mentioned in (a) - (c), the written approval of the District Officer, which approval shall be obtained prior to sampling.

(3) In the event subsection (1) requires a different sample type than subsection (2), the latter subsection shall prevail.

9. EFFLUENT QUANTITY MONITORING

(1) The owner shall maintain flow measuring devices in effluent streams discharging to Lim Lake and Frank Lake with an accuracy to within plus or minus 20 per cent of the actual discharge flowrate for the entire design range of the flow measuring devices, which must be operable under winter conditions.

(2) The owner shall measure, record and calculate the flowrate for the effluent streams referred to in subsection (1) on each day sampling is undertaken pursuant to Condition 8.

10. SURFACE WATER QUALITY MONITORING

The owner shall establish and carry out, upon commencement of operations of the works, the following surface water quality monitoring program:

(1) The surface waters named below shall be sampled, by grab sampling, at the sampling points identified on Tailings Basin Monitoring Station Plan of Item #2 of Schedule A of this certificate, in accordance with the measurement frequency specified for each parameter named below, unless otherwise required in writing by this certificate or by the District Officer:

SURFACE WATER LOCATION	FREQUENCY	PARAMETERS
Cedar Creek, at Highway 17	Monthly	Level 1 and 2
Cedar Creek, downstream of Moose Creek	Monthly	Level 1 and 2
Moose Lake	Monthly	Level 1 and 2
Frank Lake Discharge	Quarterly	Level 1 and 2
Frank Creek Discharge	Quarterly	Level 1 and 2
Creek 1, at Cedar Creek	Monthly	Level 1 and 2
Creek 2, at Cedar Creek	Monthly	Level 1 and 2
Pond 2 Discharge	Monthly	Level 1 and 2
White River, upstream of Frank Creek	Quarterly	Level 1 and 2
White River, downstream of Frank Creek	Quarterly	Level 1 and 2

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Lim Lake Discharge	Monthly	Level 1 and 2
Lee Lake Discharge	Quarterly	Level 1 and 2
Herrick Lake Discharge	Quarterly	Level 1 and 2
Hayward Lake Discharge	Quarterly	Level 1 and 2
White River, downstream of Hayward Creek	Quarterly	Level 1 and 2

Level 1 - pH, copper, lead, molybdenum, nickel, zinc, total cyanide.

Level 2 - ammonia, antimony, arsenic, iron, mercury, weak acid dissociable cyanide, alkalinity, conductivity, sulphate and suspended solids.

Quarterly sampling is to take place during the months of March, May, August and October.

(2) The methods and protocols for sampling, analysis, and recording shall conform, in order of precedence, to the methods and protocols specified in the following:

(a) the Ministry's publication "Protocol for the Sampling and Analysis of Industrial/Municipal Wastewater" (October 1991), ISBN 0-7729-8970-2, as amended from time to time by more recently published editions;

(b) the publication "Standard Methods for the Examination of Water and Wastewater" (~~17th~~ 20th edition) as amended from time to time by more recently published editions; and,

(c) in respect of any parameters not mentioned in (a) and (b), the written approval of the District Officer, which approval shall be obtained prior to sampling.

(3) In the event subsection (1) requires a different sample type than subsection (2), the latter subsection shall prevail.

11. GROUNDWATER MONITORING

The owner shall establish and carry out, upon commencement of operations of the works, the following groundwater monitoring program:

(1) The monitoring stations named below shall be sampled, by grab sampling on a ~~quarterly basis~~ in March, April, August and November of each year, with the samples being analyzed, in accordance with the protocols identified in Conditions 8 and 10, for the Level 1 and 2 parameters, as identified in Conditions 8 and 10, unless otherwise required in writing by this certificate or by the District Officer:

MONITORING STATIONS - As identified on Tailings Basin Monitoring Station Plan of Item #2 of Schedule A of this certificate.

A-1	84-07 Zones 2, 3, 5
A-2	84-09 Zones 2, 4
A-3	84-06 Zones 1, 2, 5
D-1	84-1400 Zones 1, 3
F-1	84-1500 Zone 2

(2) The elevation of the groundwater level in the monitoring stations named below shall be measured and recorded, unless otherwise required in writing by this certificate or by the District Officer:

MONITORING STATIONS - As identified on Tailings Basin Monitoring Station Plan of Item #2 of Schedule A of this certificate.

84-06 Zones 1 to 8
84-07 Zones 2 to 6
84-08 Zones 1 to 4
84-09 Zones 1, 2, 4, 5
84-1300 Zones 1 to 7
84-1400 Zones 1 to 5
84-1500 Zones 1 to 5
84-1600 Zone 1
84-1700 Zone 1
85-01 Zones 1 to 6
85-02 Zones 1 to 6
85-03 Zones 1 to 8

12. MONITORING AND RESPONSE PLAN FOR RIM DAMS

In the event that contaminated seepage discharges downstream of Dams A, D, E and F such that monitoring pursuant to Condition 10 shows that copper is present at greater than 0.25 milligrams per litre in samples obtained from Pond 2 Discharge, Creek 1 at Cedar Creek and Creek 2 at Cedar Creek, the owner shall:

(1) contain and collect the contaminated seepage and transport the seepage to the tailings basin; and

(2) forthwith investigate the source of the contaminated seepage, and undertake such measures as may be necessary to abate the seepage.

13. ROUTINE REPORTING

The owner shall prepare and submit a monitoring report to the District Officer on a monthly basis within thirty (30) days following the period being reported upon. The reports shall contain, but shall not be limited to, the following information in a format acceptable to the District Officer:

(a) a summary of all monitoring data and analytical data collected relative to the works during the reporting period and a comparison to the effluent requirements described in Condition 7; and

(b) a tabulation and description of any bypass or upset conditions which occurred during the period being reported upon.

14. ANNUAL PERFORMANCE REPORTING

The owner shall prepare and submit a performance report to the District Officer on an annual basis, and the submission shall be made no later than 120 working days following the end of each calendar year. The reports shall contain, but shall not be limited to, the following information in a format acceptable to the District Officer:

(a) a summary of all monitoring and compliance reports submitted in the reporting period, including an overview of the success and adequacy of the sewage treatment program;

(b) a comprehensive interpretation of all monitoring data and analytical data collected relative to the works during the reporting period and a comparison to the effluent requirements described in Condition 7;

(c) a summary of any effluent quality assurance or control measures undertaken in the reporting period;

(d) a summary of all maintenance carried out on any major structure, equipment, apparatus, mechanism or thing forming a part of the works;

(e) a description of any operating problems encountered and corrective actions taken during the reporting period;

(f) a summary of any proposed alteration, extension or replacement in the process or operation of the works to be completed over the next reporting period which may require approval under the *Ontario Water Resources Act*;

site

(g) a tabulation of the volume of sludge generated in the reporting period and an outline of anticipated volumes to be generated in the next reporting period;

(i) an evaluation of the calibration and maintenance procedures conducted on all monitoring equipment; and

(j) an evaluation of the need for modifications to the works to improve performance and reliability and to minimize upsets and bypasses.

15. CERTIFICATION OF REPORTS

The owner shall ensure that each monitoring and compliance report and each annual performance report submitted in accordance with this certificate is accompanied by a signed and dated certification statement from the Mine Manager, or a person designated by the Mine manager, on behalf of the owner, in the following form:

> "I certify that the information in this document and all attachments are correct, accurate and complete to the best of my knowledge",

and shall further ensure that prior to signing this statement, the owner has taken all necessary steps to properly inform him or herself of the facts so certified.

You are hereby notified that Certificate of Approval No. 4-0075-92-006 has been issued to you subject to the terms and conditions outlined therein.

The reasons for the imposition of these terms and conditions are as follows:

1. Condition no. 1 is included to define the terms used in this certificate of approval and the attached terms and conditions.

2. Condition 2 is included to make the owner, subsequent Owners, successors, assignees, and any third parties relying upon the certificate, aware that the review conducted by this Ministry and the approval granted as a result is limited in scope and should not be relied upon as an approval of the stipulated design aspects of the works.

3. Condition 3 is included to emphasize that the issuance of the certificate does not diminish any other statutory and regulatory obligations to which the owner is subject in the construction, maintenance and operation of the works.

4. Condition 4 is included to clarify how the certificate is to be judicially interpreted and specifically, to clarify that the requirements of the certificate are severable and that they prevail over supporting documentation.

5. Condition 5 is included to make the owner aware of the requirements of the *Freedom of Information and Protection of Privacy Act.*

6. Condition 6 is included in order to define the operating limits for the works to ensure that the effluent objectives and requirements will be met.

7. Condition 7 is imposed to ensure that the effluent discharged from the works to the Lim Lake and Frank Lake meets the Ministry's effluent quality requirements as specified on a continual basis thus minimizing environmental impact to the receiver.

8. Conditions 8 to 11 are included to require the owner to demonstrate on a continual basis that the quality and quantity of the effluent from the approved works is consistent with the design objectives and effluent limits specified in the certificate and that the approved works does not cause any impairment to the receiving watercourse.

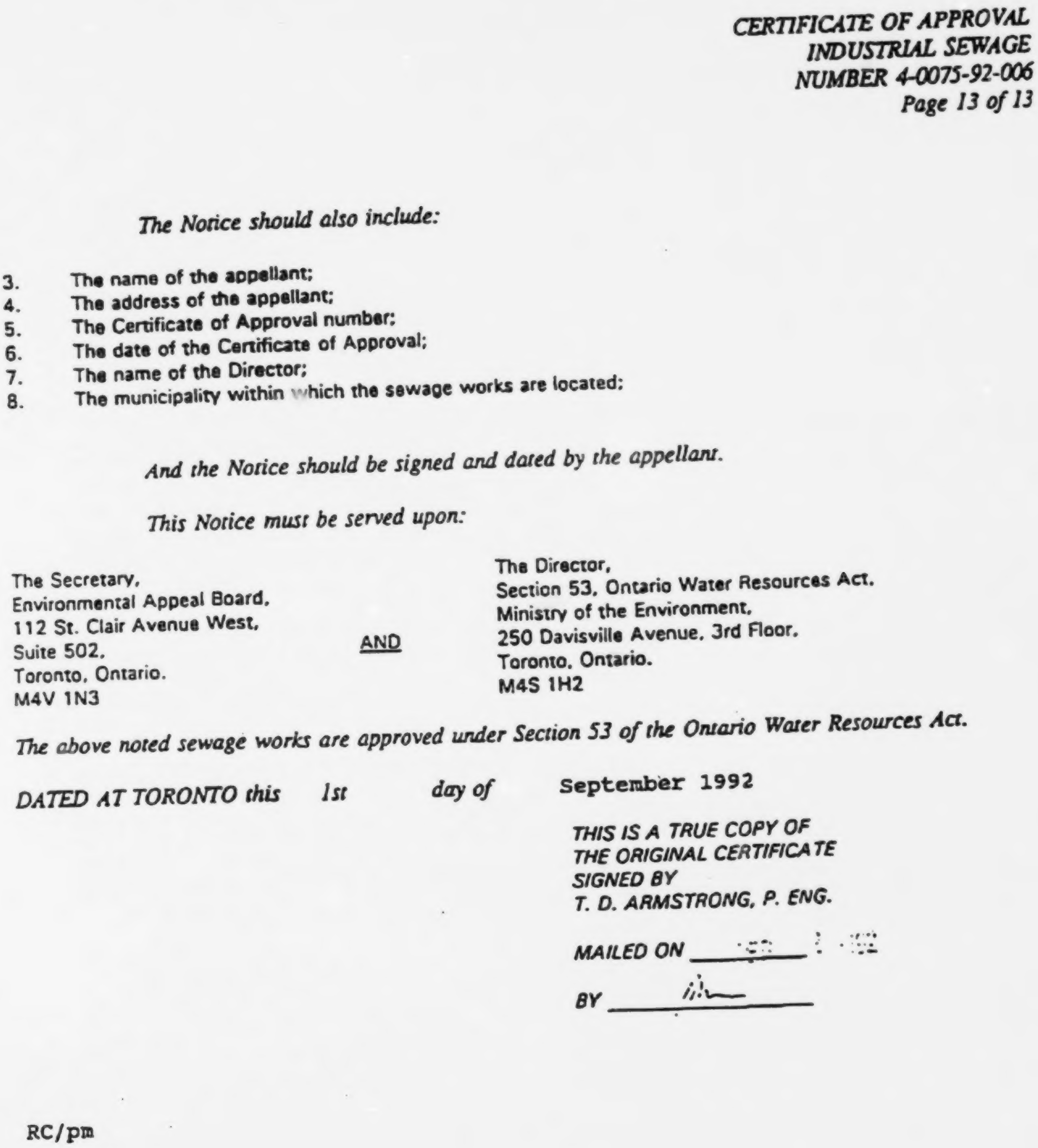
9. Condition 12 is included to ensure that if contaminated seepage is detected from the dams, the owners will initiate the monitoring and response plan designed to protect the natural environment.

10. Condition 13 to 15 are included to set out the required reporting procedures which will allow both the owner and the Ministry to be kept informed of the status of modifications being carried out under this certificate and of the operations of the works as it relates to meeting the requirements of this certificate. These conditions emphasize the necessity for proper operation and maintenance as well as care and accuracy in reporting the required information.

This certificate supersedes Certificate no. 4-061-84-006 dated August 27, 1984, as amended, and Certificate no. 4-0035-87-006 dated July 24, 1987.

You may by written notice served upon me and the Environmental Appeal Board within 15 days after receipt of this Notice, require a hearing by the Board. Section 101 of the Ontario Water Resources Act, R.S.O. 1990, Chapter 0.40, as amended, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.



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INDUSTRIAL SEWAGE
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The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the sewage works are located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary,
Environmental Appeal Board,
112 St. Clair Avenue West,
Suite 502,
Toronto, Ontario.
M4V 1N3

AND

The Director,
Section 53, Ontario Water Resources Act,
Ministry of the Environment,
250 Davisville Avenue, 3rd Floor,
Toronto, Ontario.
M4S 1H2

The above noted sewage works are approved under Section 53 of the Ontario Water Resources Act.

DATED AT TORONTO this *1st* *day of* September 1992

THIS IS A TRUE COPY OF
THE ORIGINAL CERTIFICATE
SIGNED BY
T. D. ARMSTRONG, P. ENG.

MAILED ON [illegible]

BY ______________________

RC/pm

SCHEDULE A
TO
CERTIFICATE NO. 4-0075-92-006

This Schedule forms part of Certificate no. 4-0075-92-006 and is a list of supporting information received and relied upon in the issuance of Certificate no. 4-0075-92-006.

1) Report on Supporting Documentation for Combining the David Bell and Williams Mine Tailings Basins, Hemlo, Ontario prepared by Golder Associates dated July 1992;

2) facsimilie transmission dated August 19, 1992 from Adele Faubert of Williams Operating Corporation to Mr. R. Chin of the Ministry of the Environment containing a drawing titled Tailings Basin Monitoring Station Plan;

Williams Mine

3) Application for the Approval of Plans and Specifications for the Construction of Works for the Collection, Transmission, Treatment and Discharge of Industrial Wastewater - Section 24, Ontario Water Resources Act submitted by Lac Minerals Ltd. dated December 18, 1984, plans, specifications reports and other information;

4) Application for Approval of Plans and Specifications for the construction of Works for the Collection, Transmission, Treatment and Discharge of Industrial Wastewater signed by S. Brown (Chief Mine Engineer), Williams Operating Corp., dated June 25, 1990;

5) the report entitled Monitoring and Response Plan, North Rim Dams D, E and F, Molson Tailings Basin, prepared by Golder Associates;

6) drawings entitled Seepage Pathways and Water Quality Monitoring Locations: North Rim Dams, and Typical Cross-sections Dams D, E, and F, prepared by Golder Associates;

7) drawings entitled Seepage Pathways and Water Quality Monitoring Locations: North Rim Dams, and Schematic Cross-Section, Interceptor Dyke and Collection Sump, North Rim Dams, prepared by Golder Associates;

8) Tailings Dam Construction, Dams D, E, & F drawings nos. G-230-36-202 to 213, revised January 1992 and specification no. G-230-36-301 (Rev. C), all prepared by Golder Associates;

9) Certificate of Approval no. 4-099-84-856 dated June 13, 1985, as amended by Notices dated May 14, 1990 (Rev. 1), May 17, 1991 (Rev. 2), March 9, 1992 (Rev. 3);

SCHEDULE A
TO
CERTIFICATE NO. 4-0075-92-006

10) Application for the Approval of Plans and Specifications for the Construction of Works for the Collection, Transmission, Treatment and Discharge of Industrial Wastewater - Section 24, Ontario Water Resources Act submitted by Lac Minerals Ltd. dated March 23, 1987 and the following:

- Lac Minerals Design Criteria dated Dec. 11/86
- Golder Associates Estimated Flow Requirements dated Feb.16/87
- Wright Eng. Ltd. Process Design
- Golder Associates Effluent Treatment Pipelines dated Jan.23/87
- Lac Minerals Ltd. Effluent Treatment with Peroxide dated Feb. 6/87
- Lac Minerals Ltd. Water Quality Analysis
- Senes Consultants Effluent Monitoring Programme dated Jul. 1985
- Lac Minerals Ltd. Process Description/Flowsheet dated March 1987
- drawings D-3030-100-7300 (rev. A), D-3030-100-7301 to 7305 (rev. C), D-3030-100-1301 & 1302 (rev.C) and D-3030-100-1305 (rev.B);

11) Certificate of Approval no. 4-0035-87-006 dated July 24, 1987;

David Bell Mine

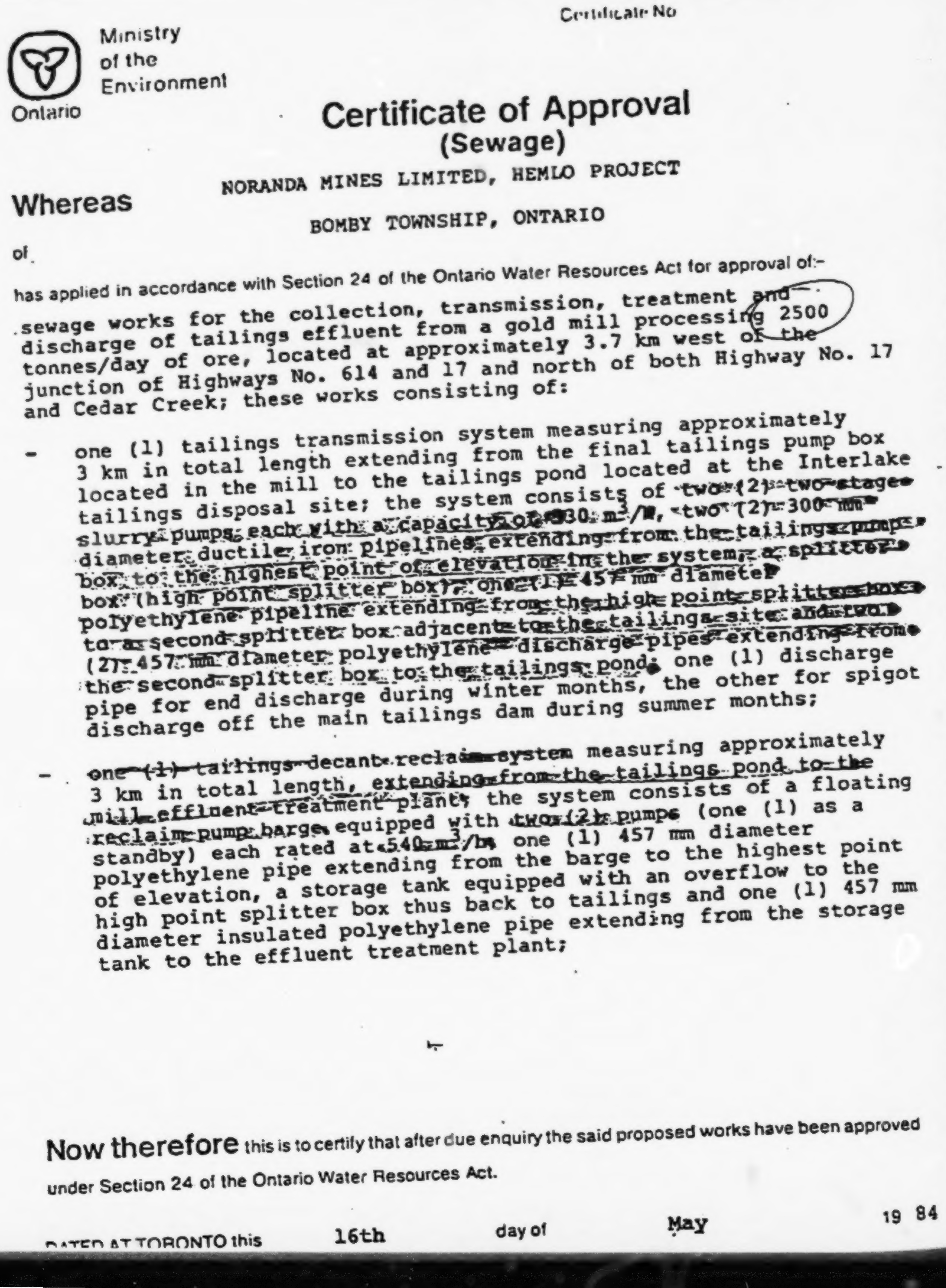
12) Application for the Approval of Plans and Specifications for the Construction of Works for the Collection, Transmission, Treatment and Discharge of Industrial Wastewater - Section 24, Ontario Water Resources Act submitted by Teck-Corona Operating Corporation dated December 5, 1984 and submitted plans, reports specifications and correspondence;

13) Application for the Approval of Plans and Specifications for the Construction of Works for the Collection, Transmission, Treatment and Discharge of Industrial Wastewater - Section 24, Ontario Water Resources Act submitted by Teck-Corona Operating Corporation dated July 15, 1984 and submitted plans, reports specifications and correspondence;

14) Certificate of Approval no. 4-095-84-877 dated April 2, 1987 as amended by Notices dated September 11, 1989 (Rev. 1), September 10, 1990 (Rev. 2);

15) Application for the Approval of Plans and Specifications for the Construction of Works for the Collection, Transmission, Treatment and Discharge of Industrial Wastewater - Section 24, Ontario Water Resources Act submitted by Teck-Corona Operating Corporation dated July 15, 1984 and submitted plans, reports specifications and correspondence;

16) Certificate of Approval no. 4-061-84-006 dated August 27, 1984 as amended by Notice dated April 25 1990;



Certificate No

Ministry
of the
Environment
Ontario

Certificate of Approval
(Sewage)

Whereas NORANDA MINES LIMITED, HEMLO PROJECT

of BOMBY TOWNSHIP, ONTARIO

has applied in accordance with Section 24 of the Ontario Water Resources Act for approval of:-

sewage works for the collection, transmission, treatment and
discharge of tailings effluent from a gold mill processing 2500
tonnes/day of ore, located at approximately 3.7 km west of the
junction of Highways No. 614 and 17 and north of both Highway No. 17
and Cedar Creek; these works consisting of:

- one (1) tailings transmission system measuring approximately
3 km in total length extending from the final tailings pump box
located in the mill to the tailings pond located at the Interlake
tailings disposal site; the system consists of two (2) two-stage
slurry pumps each with a capacity of 330 m^3/h, two (2) 300 mm
diameter ductile iron pipelines extending from the tailings pump
box to the highest point of elevation in the system, a splitter
box (high point splitter box), one (1) 457 mm diameter
polyethylene pipeline extending from the high point splitter box
to a second splitter box adjacent to the tailings site and two
(2) 457 mm diameter polyethylene discharge pipes extending from
the second splitter box to the tailings pond; one (1) discharge
pipe for end discharge during winter months, the other for spigot
discharge off the main tailings dam during summer months;

- one (1) tailings decant reclaim system measuring approximately
3 km in total length, extending from the tailings pond to the
mill effluent treatment plant; the system consists of a floating
reclaim pump barge equipped with two (2) pumps (one (1) as a
standby) each rated at 540 m^3/h, one (1) 457 mm diameter
polyethylene pipe extending from the barge to the highest point
of elevation, a storage tank equipped with an overflow to the
high point splitter box thus back to tailings and one (1) 457 mm
diameter insulated polyethylene pipe extending from the storage
tank to the effluent treatment plant;

Now therefore this is to certify that after due enquiry the said proposed works have been approved under Section 24 of the Ontario Water Resources Act.

DATED AT TORONTO this 16th day of May 19 84

Ministry
of the
Environment
Ontario

(Continued)

Certificate of Approval
(Sewage)

Whereas .... - 2 -......................

of

has applied in accordance with Section 24 of the Ontario Water Resources Act for approval of:-

- [redacted] pond located at the Interlake tailings [redacted] seepage collection system; the tailings pond is contained by dams constructed with a cement grout curtain extending into the bedrock and a polyethylene liner attached to the grout curtain and extending up the dams constructed to the height of 345 m elevation, referenced on Drawing No. 67-22-104 Revision 0, by Geocon; the seepage collection pond is contained by a dam of similar construction and is equipped [redacted] containing two (2) pumps rated at 66 m^3/h, each; pumps discharge to the floating reclaim pump barge;

- [redacted] plant consisting of a sulfur dioxide/ [redacted] stage and a metal precipitation stage; the sulfur dioxide/air cyanide destruction stage consists of [redacted] measuring 6.3 m in diameter and 7 m high, each equipped with an agitator, a pH meter associated with a lime feed system and a sulfur dioxide/air injection system via the agitator shaft, [redacted] agitated clarifier feed tank, one (1) [redacted] in diameter and one (1) cyanide free [redacted]; the metal precipitation stage consists of three (3) reactor tanks measuring 6.3 m in diameter and 7 m high, each equipped with an agitator and a pH meter associated with a lime feed system, one (1) agitated clarifier feed tank, one (1) clarifier measuring 32 m in diameter and one (1) treated decant surge tank;

- [redacted] discharge system measuring approximately 3 km in total length [redacted] the treated decant surge tank [redacted]; the system consists of two (2) pumps (one (1) as a [redacted] capacity of 316 m^3/h and [redacted] 300 mm [redacted] pipeline;

- one (1) [redacted] complete with a pipe platform and spill containment ditches extending the entire length of the tailings and reclaim lines; [redacted] containment ditches discharge to the [redacted] storm water sedimentation pond (flow [redacted] point); the pipe platform crosses Cedar Creek by means of a [redacted] complete with spill containment; and

Now therefore this is to certify that after due enquiry the said proposed works have been approved under Section 24 of the Ontario Water Resources Act.

DATED AT TORONTO this 16th day of May 1984

of the
Environment
Ontario

(Continued)

Certificate of Approval
(Sewage)

Whereas.................... - 3 - ....

of

has applied in accordance with Section 24 of the Ontario Water Resources Act for approval of:-

- all other piping, pumps, sumps, monitoring equipment and appurtenances,

[redacted] discharge of approximately 316 [redacted] with the "Effluent Guidelines for [redacted] of Ontario, 1979", as published in the "Guidelines for Environmental Control in the Ontario Mining Industry, October, 1981".

All in accordance with the application dated October 20, 1983, plans, drawings, reports, correspondences and specifications submitted by Noranda Mines Limited and Geocon Inc., subject to the following special terms and conditions which are considered necessary by the undersigned.

Special Terms and Conditions:

1. Tailings dams and seepage collection systems shall be constructed in accordance with principles and material specifications as outlined in the attached Schedule "A". ✓

2. No tailings are to be deposited in the proposed tailings disposal pond until a final design report with plans and specifications detailing the tailings pond and seepage collection system development including site preparation, scheduling and operation is submitted to and approved by the Director of the Environmental Approvals and Project Engineering Branch of the Ministry of the Environment.

3. [redacted] deposited in the tailings disposal pond [redacted] for monitoring surface and groundwater [redacted] by the Director of the [redacted] Ministry of the Environment. The detailed program should include but not be limited to locations of monitoring stations on Cedar Creek, number and location of monitoring wells, sampling frequency and parameters to be analysed for. The monitoring program can be modified from time to time as required by the Director of the Northwestern Region of the Ministry of the Environment.

See SW-TD-1 (Names report + reply to it from MOE)

Now therefore this is to certify that after due enquiry the said proposed works have been approved under Section 24 of the Ontario Water Resources Act.

DATED AT TORONTO this 16th day of May 1984

Certificate No 4-072-83-846
(Continued)

Ministry
of the
Environment
Ontario

Certificate of Approval
(Sewage)

Whereas .... - 4 - ....

of

has applied in accordance with Section 24 of the Ontario Water Resources Act for approval of:-

4. ~~If, at any time,~~ the monitoring program indicates that the ~~impact of seepage will cause the water quality in Cedar Creek to exceed water quality objectives prescribed~~ by the "Water Management Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment" publication, November 1978, then ~~the company shall notify the Director of the Northwestern Region of the Ministry of the Environment immediately.~~ If deemed necessary by the Director, after he has taken into consideration exceedences of the predicted Cedar Creek and Black River concentrations of the parameters in Table 2 and Table 3 of Schedule "A", the company will, without delay, develop and implement a contingency program to mitigate the seepage in a time period satisfactory to the Director. This contingency program may include but is not restricted to measures such as the use of grout curtains, purge well systems, construction of additional seepage collection systems etc. ✓

5. At least six months preceding the construction of the extension of the tailings pond the company shall submit the results of a drilling program for expansion of the tailings dams, and construction of additional dams to the Director of the Environmental Approvals and Project Engineering Branch of the Ministry of the Environment for review. If the data indicates the necessity for additional mitigating measures not included in Schedule A, appropriate designs for these additional mitigating measures will be submitted for approval. If additional mitigating measures are required, no construction of tailings dam expansion will be undertaken prior to the receipt of an amended Certificate of Approval for such mitigating measures.

see SW-TD-2

6. Before commencing operation of the sewage works approved herein, Noranda Mines Limited shall submit a treated effluent monitoring program acceptable to the Regional Director of the Northwestern Region of the Ministry of the Environment.

7. Noranda Mines Limited will provide the Director of the Northwestern Region of the Ministry of the Environment with an annual progress report which will include the results of an

Now therefore this is to certify that after due enquiry the said proposed works have been approved under Section 24 of the Ontario Water Resources Act.

DATED AT TORONTO this 16th day of May 19 84

Ministry
of the
Environment
Ontario

Certificate No 4-072-83-846
(Continued)

Certificate of Approval
(Sewage)

Whereas .... - 5 - ....

of

has applied in accordance with Section 24 of the Ontario Water Resources Act for approval of:-

interpretative analysis of all monitoring programs specified in this approval. The [redacted] ~~report is to be submitted by the~~ end [redacted], covering the previous calendar year's data.

8. Noranda Mines Limited shall operate the sewage works approved herein with the aim of reducing the concentrations of antimony and molybdenum, in the effluent. The actions taken and the results achieved shall be described and included in the performance report required under Condition 9.

9. Within eighteen (18) months after commencing operations of the sewage works, resulting in discharge of treated effluent to Lim Lake, Noranda Mines Limited shall submit a performance report to the Director of the Northwestern Region of the Ministry of the Environment, detailing the:

   a) effectiveness of the approved works for controlling total cyanide and metals, and
   b) actions taken for minimizing antimony and molybdenum in the treated effluent.

10. By July 1, 1984 a contingency notification plan must be put in place with downstream users of the Black and White Rivers watersheds to the satisfaction of the Director of the Northwestern Region of the Ministry of the Environment.

11. At least six (6) months prior to the permanent closure of the mill, the Company shall submit a detailed report for the satisfaction of the Director of the Northwestern Region on the actions planned for the permanent closure of the operations and the tailings area to address certain concerns, including but not restricted to the following:

- prevention and mitigation of environmental impact of seepage
- long term maintenance and reporting of seepage control system.
- renovation and revegetation of tailings area.
- restoration of mill site.

Now therefore this is to certify that after due enquiry the said proposed works have been approved under Section 24 of the Ontario Water Resources Act.

DATED AT TORONTO this 16th day of May 1984

Appendix 2

Treated Effluent Data for David Bell Mine and Williams Mine

TABLE 2.2
MONITORING RESULTS
WILLIAMS MINE
TAILINGS EFFLUENT

Description	Lab pH (pH units)	Specific Conductivity (umhos/cm)	Suspended Solids (mg/l)	Total Cyanide (mg/l)	Total Antimony (mg/l)
mean 1990	7.700	2516	1.400	0.153	0.500
mean 1991	7.500	2465	2.100	0.075	0.460
mean 1992	7.270	2425	1.400	0.075	0.381
mean 1993	7.410	2419	1.330	0.200	0.363
Standard deviation	0.208	305.6	0.550	0.160	0.137
Maximum - 1993	7.780	3015	3.600	0.720	0.593
Minimum - 1993	6.580	1410	1.100	0.028	0.118
parameter limit			15.0 mg/L	2.0 mg/L	

Description	Total Arsenic (mg/l)	Ammonia as N (mg/l)	Total Alkalinity (mg/l)	Total Copper (mg/l)	Total Iron (mg/l)
mean 1990	0.006	15.4	42	0.078	0.300
mean 1991	0.005	16.13	48	0.010	0.260
mean 1992	0.003	16.06	35	0.012	0.274
mean 1993	0.003	15.64	38	0.040	0.264
Standard deviation	0.000	2.164	8	0.052	0.295
Maximum - 1993	0.003	18.910	51	0.326	1.100
Minimum - 1993	0.003	10.620	21	0.004	0.046
parameter limit	0.5 mg/L	20.0 mg/L		0.3 mg/L	1 mg/L

Description	Total Lead (mg/l)	Total Molybdenum (mg/l)	Total Nickel (mg/l)	Total Zinc (mg/l)
mean 1990	0.030	0.800	0.052	0.008
mean 1991	0.050	0.760	0.061	0.007
mean 1992	0.035	0.590	0.061	0.009
mean 1993	0.041	0.565	0.109	0.009
Standard deviation	0.019	0.153	0.040	0.003
Maximum - 1993	0.089	0.847	0.220	0.020
Minimum - 1993	0.015	0.212	0.060	0.008
parameter limit	0.2 mg/L		0.5 mg/L	0.5 mg/L

Parameters with no limits not included in permit

TECK-CORONA OPERATING CORPORATION
DAVID BELL MINE AQUAMIN CASE STUDY
DATA

SAMPLE SITE: FINAL TREATED EFFLUENT

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l	TOTAL ZINC mg/l
SEP 1985 - DEC 1985						
MEAN	0.208	0.0017	0.152	0.008	0.038	0.012
MINIMUM VALUE	0.013	0.0011	0.009	0.003	0.001	0.005
MAXIMUM VALUE	0.750	0.0025	0.850	0.010	0.050	0.062
JAN 1986 - DEC 1986						
MEAN	0.370	0.0044	0.143		0.001	0.007
MINIMUM VALUE	0.035	0.0012	0.017		0.001	0.005
MAXIMUM VALUE	2.650	0.0130	1.010		0.001	0.019
JAN 1987 - DEC 1987						
MEAN	0.719	0.0017	0.128	0.053	0.002	0.019
MINIMUM VALUE	0.009	0.0002	0.003	0.015	0.001	0.005
MAXIMUM VALUE	4.060	0.0100	1.000	0.090	0.008	0.150
JAN 1988 - DEC 1988						
MEAN	0.248	0.0025	0.102			0.010
MINIMUM VALUE	0.009	0.0001	0.002			0.005
MAXIMUM VALUE	1.920	0.0140	0.950			0.029
JAN 1989 - DEC 1989						
MEAN	0.486	0.0034	0.248	0.009	0.001	0.006
MINIMUM VALUE	0.005	0.0010	0.001	0.009	0.001	0.005
MAXIMUM VALUE	2.450	0.0150	2.240	0.009	0.001	0.014
JAN 1990 - DEC 1990						
MEAN	0.213	0.005	0.010			0.007
MINIMUM VALUE	0.008	0.002	0.005			0.005
MAXIMUM VALUE	1.920	0.010	0.063			0.035
JAN 1991 - DEC 1991						
MEAN	0.136	0.005	0.006	0.065	0.002	0.010
MINIMUM VALUE	0.005	0.005	0.005	0.065	0.002	0.005
MAXIMUM VALUE	0.440	0.005	0.020	0.065	0.002	0.120
JAN 1992 - DEC 1992						
MEAN	0.109	0.002	0.007	0.054	0.058	0.074
MINIMUM VALUE	0.010	0.001	0.004	0.022	0.027	0.008
MAXIMUM VALUE	0.675	0.003	0.033	0.118	0.096	0.262
JAN 1993 - DEC 1993						
MEAN	0.086	0.003	0.007	0.065	0.054	0.041
MINIMUM VALUE	0.007	0.003	0.004	0.016	0.015	0.008
MAXIMUM VALUE	0.611	0.003	0.086	0.310	0.099	0.157
JAN 1994 - DEC 1994						
MEAN	0.0750	0.0025	0.0187	0.050	0.038	0.0358
MINIMUM VALUE	0.0048	0.0025	0.0087	0.018	0.029	0.0097
MAXIMUM VALUE	0.4580	0.0025	0.1370	0.193	0.096	0.1770

TECK-CORONA OPERATING CORPORATION
DAVID BELL MINE AQUAMIN CASE STUDY
DATA

SAMPLE SITE: FINAL TREATED EFFLUENT

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l
JAN 1992 - DEC 1992					
MEAN	0.1090	0.0021	0.0070	0.0538	0.0577
MINIMUM VALUE	0.010	0.001	0.004	0.022	0.027
MAXIMUM VALUE	0.675	0.003	0.033	0.118	0.096

SAMPLE SITE: LIM LAKE DISCHARGE

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l
JAN 1992 - DEC 1992					
MEAN	0.00729	0.0018	0.0083	0.0544	0.0392
MINIMUM VALUE	0.0035	0.001	0.004	0.046	0.025
MAXIMUM VALUE	0.0300	0.003	0.017	0.063	0.055

SAMPLE SITE: LEE LAKE DISCHARGE

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l
JAN 1992 - DEC 1992					
MEAN	0.00401	0.0018	0.0053	0.0438	0.0369
MINIMUM VALUE	0.0035	0.001	0.004	0.029	0.020
MAXIMUM VALUE	0.0100	0.003	0.009	0.056	0.072

SAMPLE SITE: HERRICK LAKE DISCHARGE

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l
JAN 1992 - DEC 1992					
MEAN	0.00350	0.0020	0.0043	0.0090	0.0150
MINIMUM VALUE	0.0035	0.001	0.004	0.009	0.015
MAXIMUM VALUE	0.0035	0.003	0.005	0.009	0.015

TECK-CORONA OPERATING CORPORATION
DAVID BELL MINE AQUAMIN CASE STUDY
DATA

SAMPLE SITE: FINAL TREATED EFFLUENT

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l
JAN 1993 - DEC 1993					
MEAN	0.0855	0.0030	0.0074	0.0650	0.0544
MINIMUM VALUE	0.007	0.003	0.004	0.016	0.015
MAXIMUM VALUE	0.611	0.003	0.086	0.310	0.099

SAMPLE SITE: LIM LAKE DISCHARGE

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l
JAN 1993 - DEC 1993					
MEAN	0.01520	0.0030	0.0187	0.0539	0.0399
MINIMUM VALUE	0.0035	0.003	0.006	0.009	0.015
MAXIMUM VALUE	0.0940	0.003	0.048	0.081	0.060

SAMPLE SITE: LEE LAKE DISCHARGE

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l
JAN 1993 - DEC 1993					
MEAN	0.00761	0.0030	0.0074	0.0408	0.0370
MINIMUM VALUE	0.0035	0.003	0.004	0.009	0.012
MAXIMUM VALUE	0.0230	0.003	0.017	0.066	0.068

SAMPLE SITE: HERRICK LAKE DISCHARGE

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l
JAN 1993 - DEC 1993					
MEAN	0.00350	0.0030	0.0040	0.0090	0.0150
MINIMUM VALUE	0.0035	0.003	0.004	0.009	0.015
MAXIMUM VALUE	0.0035	0.003	0.004	0.009	0.015

TECK-CORONA OPERATING CORPORATION
DAVID BELL MINE AQUAMIN CASE STUDY
DATA

SAMPLE SITE: FINAL TREATED EFFLUENT

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l
JAN 1994 - NOV 1994					
MEAN	0.07796	0.00250	0.01884	0.0490	0.0388
MINIMUM VALUE	0.0048	0.0025	0.0087	0.018	0.029
MAXIMUM VALUE	0.4580	0.0025	0.1370	0.193	0.096

SAMPLE SITE: LIM LAKE DISCHARGE

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l
JAN 1994 - NOV 1994					
MEAN	0.03675	0.00250	0.0428	0.0501	0.0347
MINIMUM VALUE	0.0048	0.0025	0.014	0.018	0.029
MAXIMUM VALUE	0.1360	0.0025	0.084	0.088	0.094

SAMPLE SITE: LEE LAKE DISCHARGE

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l
JAN 1994 - NOV 1994					
MEAN	0.02111	0.00250	0.0310	0.0413	0.0356
MINIMUM VALUE	0.0048	0.0025	0.010	0.018	0.029
MAXIMUM VALUE	0.0790	0.0025	0.326	0.078	0.071

SAMPLE SITE: HERRICK LAKE DISCHARGE

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l
JAN 1994 - NOV 1994					
MEAN	0.00480	0.00250	0.00870	0.0180	0.0290
MINIMUM VALUE	0.0048	0.0025	0.0087	0.018	0.029
MAXIMUM VALUE	0.0048	0.0025	0.0087	0.018	0.029

WILLIAMS OPERATING CORPORATION
AQUAMIN - HEMLO CASE STUDY

SAMPLE SITE: M3–TREATED EFFLUENT

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL LEAD mg/l	TOTAL NICKEL mg/l	TOTAL ZINC mg/l
MAY 1987 – NOV 1987						
MEAN	0.1070	0.080	0.1000	0.015	0.0340	0.0030
MINIMUM VALUE	0.101	0.08	0.087	0.01	0.002	0.002
MAXIMUM VALUE	0.113	0.08	0.113	0.02	0.066	0.004
MAY 1988 – NOV 1988						
MEAN	0.1139	0.097	0.012	0.024	0.049	0.0030
MINIMUM VALUE	0.005	0.01	0.01	0.01	0.02	0.002
MAXIMUM VALUE	0.457	0.21	0.08	0.04	0.08	0.020
MAY 1989 – NOV 1989						
MEAN	0.112	0.203	0.0248	0.024	0.070	0.0076
MINIMUM VALUE	0.02	0.04	0.005	0.02	0.03	0.002
MAXIMUM VALUE	0.66	0.52	0.432	0.03	0.14	0.019
MAY 1990 – NOV 1990						
MEAN	0.1532	0.0058	0.0776	0.0245	0.0520	0.0075
MINIMUM VALUE	0.029	0.005	0.005	0.010	0.020	0.005
MAXIMUM VALUE	0.960	0.014	1.000	0.047	0.140	0.058
MAY 1991 – NOV 1991						
MEAN	0.0753	0.0050	0.0103	0.0471	0.0612	0.0070
MINIMUM VALUE	0.030	0.005	0.005	0.014	0.029	0.005
MAXIMUM VALUE	0.150	0.005	0.023	0.108	0.100	0.028
MAY 1992 – NOV 1992						
MEAN	0.0908	0.0030	0.0137	0.0369	0.0635	0.0094
MINIMUM VALUE	0.020	0.003	0.004	0.018	0.044	0.008
MAXIMUM VALUE	0.280	0.003	0.062	0.051	0.081	0.030
MAY 1993 – NOV 1993						
MEAN	0.1987	0.0030	0.0396	0.0396	0.1085	0.0097
MINIMUM VALUE	0.028	0.003	0.004	0.010	0.039	0.006
MAXIMUM VALUE	0.720	0.003	0.326	0.089	0.220	0.020
MAY 1994 – NOV 1994						
MEAN	0.1721	0.00250	0.0409	0.0308	0.2060	0.01674
MINIMUM VALUE	0.056	0.0025	0.010	0.029	0.094	0.0097
MAXIMUM VALUE	0.660	0.0025	0.084	0.054	0.284	0.0390

WILLIAMS OPERATING CORPORATION
AQUAMIN - HEMLO CASE STUDY

SAMPLE SITE: M4—FRANK LAKE OUTLET

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL LEAD mg/l	TOTAL NICKEL mg/l	TOTAL ZINC mg/l
JAN 1987 – DEC 1987						
MEAN	0.0134	0.036	0.0050	0.0072	0.0348	0.0132
MINIMUM VALUE	0.009	0.01	0.005	0.002	0.002	0.002
MAXIMUM VALUE	0.028	0.08	0.005	0.010	0.080	0.030
JAN 1988 – DEC 1988						
MEAN	0.0225	0.058	0.0052	0.012	0.0238	0.0050
MINIMUM VALUE	0.011	0.04	0.005	0.01	0.012	0.003
MAXIMUM VALUE	0.032	0.10	0.006	0.02	0.043	0.008
JAN 1989 - DEC 1989						
MEAN	0.0110	0.065	0.0050	0.0118	0.0300	0.0070
MINIMUM VALUE	0.008	0.04	0.005	0.005	0.021	0.006
MAXIMUM VALUE	0.013	0.14	0.005	0.018	0.049	0.008
JAN 1990 – DEC 1990						
MEAN	0.0095	0.0060	0.0065	0.0160	0.017	0.0080
MINIMUM VALUE	0.005	0.005	0.005	0.012	0.01	0.005
MAXIMUM VALUE	0.016	0.008	0.010	0.020	0.02	0.011
JAN 1991 – DEC 1991						
MEAN	0.0067	0.0050	0.0078	0.0200	0.0200	0.0130
MINIMUM VALUE	0.005	0.005	0.005	0.012	0.014	0.010
MAXIMUM VALUE	0.009	0.005	0.016	0.027	0.025	0.018
JAN 1992 – DEC 1992						
MEAN	0.0085	0.0025	0.0113	0.0258	0.0392	0.0085
MINIMUM VALUE	0.005	0.001	0.004	0.023	0.018	0.008
MAXIMUM VALUE	0.014	0.003	0.017	0.029	0.078	0.009
JAN 1993 – DEC 1993						
MEAN	0.00975	0.0030	0.0083	0.0263	0.0352	0.0083
MINIMUM VALUE	0.0035	0.003	0.004	0.015	0.009	0.008
MAXIMUM VALUE	0.0190	0.003	0.011	0.056	0.058	0.009
JAN 1994 – DEC 1994						
MEAN	0.02645	0.00250	0.01468	0.0290	0.0715	0.00970
MINIMUM VALUE	0.0048	0.0025	0.0087	0.029	0.023	0.0097
MAXIMUM VALUE	0.0420	0.0025	0.0190	0.029	0.121	0.0097

WILLIAMS OPERATING CORPORATION
AQUAMIN - HEMLO CASE STURY

SAMPLE SITE: M5-FRANK CREEK DISCHARGE

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL LEAD mg/l	TOTAL NICKEL mg/l	TOTAL ZINC mg/l
JAN 1987 - DEC 1987						
MEAN	0.0117	0.045	0.0050	0.010	0.0132	0.0020
MINIMUM VALUE	0.006	0.04	0.005	0.01	0.002	0.002
MAXIMUM VALUE	0.021	0.06	0.005	0.01	0.044	0.002
JAN 1988 - DEC 1988						
MEAN	0.0140	0.057	0.0050	0.010	0.0132	0.0040
MINIMUM VALUE	0.005	0.04	0.005	0.01	0.002	0.002
MAXIMUM VALUE	0.021	0.08	0.005	0.01	0.029	0.006
JAN 1989 - DEC 1989						
MEAN	0.0067	0.068	0.0050	0.0093	0.0342	0.0053
MINIMUM VALUE	0.005	0.04	0.005	0.004	0.002	0.002
MAXIMUM VALUE	0.012	0.15	0.005	0.014	0.065	0.007
JAN 1990 - DEC 1990						
MEAN	0.0050	0.0055	0.0052	0.0147	0.0105	0.0058
MINIMUM VALUE	0.005	0.005	0.005	0.008	0.010	0.005
MAXIMUM VALUE	0.005	0.006	0.006	0.022	0.012	0.008
JAN 1991 - DEC 1991						
MEAN	0.0060	0.0050	0.0142	0.0132	0.0097	0.0082
MINIMUM VALUE	0.005	0.005	0.005	0.010	0.007	0.005
MAXIMUM VALUE	0.009	0.005	0.042	0.021	0.012	0.012
JAN 1992 - DEC 1992						
MEAN	0.00363	0.0025	0.0073	0.0160	0.0197	0.0083
MINIMUM VALUE	0.0035	0.001	0.004	0.015	0.009	0.008
MAXIMUM VALUE	0.0040	0.003	0.011	0.017	0.042	0.009
JAN 1993 - DEC 1993						
MEAN	0.00613	0.0030	0.0090	0.0222	0.0155	0.0080
MINIMUM VALUE	0.0035	0.003	0.004	0.015	0.009	0.008
MAXIMUM VALUE	0.0080	0.003	0.016	0.044	0.022	0.008
JAN 1994 - DEC 1994						
MEAN	0.01020	0.00250	0.01717	0.0290	0.0272	0.00970
MINIMUM VALUE	0.0048	0.0025	0.0087	0.029	0.018	0.0097
MAXIMUM VALUE	0.0200	0.0025	0.0240	0.029	0.040	0.0097

WILLIAMS OPERATING CORPORATION
AQUAMIN - HEMLO CASE STUDY

SAMPLE SITE: M6-WHITE RIVER UPSTREAM

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL LEAD mg/l	TOTAL NICKEL mg/l	TOTAL ZINC mg/l
JAN 1987 - DEC 1987						
MEAN	0.0050	0.040	0.0050	0.012	0.0137	0.0035
MINIMUM VALUE	0.005	0.04	0.005	0.01	0.002	0.002
MAXIMUM VALUE	0.005	0.04	0.005	0.02	0.038	0.008
JAN 1988 - DEC 1988						
MEAN	0.0103	0.040	0.0050	0.015	0.0068	0.0100
MINIMUM VALUE	0.005	0.04	0.005	0.01	0.003	0.002
MAXIMUM VALUE	0.017	0.04	0.005	0.02	0.010	0.032
JAN 1989 - DEC 1989						
MEAN	0.0050	0.042	0.0050	0.0075	0.0095	0.0028
MINIMUM VALUE	0.005	0.04	0.005	0.001	0.002	0.002
MAXIMUM VALUE	0.005	0.05	0.005	0.010	0.016	0.005
JAN 1990 - DEC 1990						
MEAN	0.0050	0.0052	0.0050	0.0120	0.010	0.0050
MINIMUM VALUE	0.005	0.005	0.005	0.010	0.01	0.005
MAXIMUM VALUE	0.005	0.006	0.005	0.018	0.01	0.005
JAN 1991 - DEC 1991						
MEAN	0.0050	0.0050	0.0075	0.0153	0.010	0.0112
MINIMUM VALUE	0.005	0.005	0.005	0.010	0.01	0.005
MAXIMUM VALUE	0.005	0.005	0.015	0.027	0.01	0.030
JAN 1992 - DEC 1992						
MEAN	0.00350	0.0025	0.0093	0.0150	0.0145	0.0080
MINIMUM VALUE	0.0035	0.001	0.004	0.015	0.009	0.008
MAXIMUM VALUE	0.0035	0.003	0.015	0.015	0.031	0.008
JAN 1993 - DEC 1993						
MEAN	0.00463	0.0030	0.0040	0.0155	0.0090	0.0080
MINIMUM VALUE	0.0035	0.003	0.004	0.015	0.009	0.008
MAXIMUM VALUE	0.0080	0.003	0.004	0.017	0.009	0.008
JAN 1994 - DEC 1994						
MEAN	0.00480	0.00250	0.00928	0.0290	0.0180	0.01328
MINIMUM VALUE	0.0048	0.0025	0.0087	0.029	0.018	0.0097
MAXIMUM VALUE	0.0048	0.0025	0.0110	0.029	0.018	0.0240

WILLIAMS OPERATING CORPORATION
AQUAMIN - HEMLO CASE STUDY

SAMPLE SITE: M7-WHITE RIVER DOWNSTREAM

Date	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL LEAD mg/l	TOTAL NICKEL mg/l	TOTAL ZINC mg/l
JAN 1987 - DEC 1987						
MEAN	0.0075	0.040	0.0050	0.0152	0.0193	0.0020
MINIMUM VALUE	0.005	0.04	0.005	0.010	0.002	0.002
MAXIMUM VALUE	0.010	0.04	0.005	0.021	0.048	0.002
JAN 1988 - DEC 1988						
MEAN	0.0095	0.040	0.0050	0.015	0.0075	0.0028
MINIMUM VALUE	0.005	0.04	0.005	0.01	0.002	0.002
MAXIMUM VALUE	0.015	0.04	0.005	0.02	0.016	0.004
JAN 1989 - DEC 1989						
MEAN	0.0050	0.040	0.0050	0.0070	0.0073	0.0025
MINIMUM VALUE	0.005	0.04	0.005	0.001	0.002	0.002
MAXIMUM VALUE	0.005	0.04	0.005	0.016	0.013	0.004
JAN 1990 - DEC 1990						
MEAN	0.0050	0.0058	0.0050	0.0110	0.010	0.0050
MINIMUM VALUE	0.005	0.005	0.005	0.010	0.01	0.005
MAXIMUM VALUE	0.005	0.008	0.005	0.014	0.01	0.005
JAN 1991 - DEC 1991						
MEAN	0.0050	0.0050	0.0070	0.0115	0.010	0.0088
MINIMUM VALUE	0.005	0.005	0.005	0.010	0.01	0.005
MAXIMUM VALUE	0.005	0.005	0.013	0.016	0.01	0.016
JAN 1992 - DEC 1992						
MEAN	0.00350	0.0025	0.0070	0.0150	0.0117	0.0080
MINIMUM VALUE	0.0035	0.001	0.004	0.015	0.009	0.008
MAXIMUM VALUE	0.0035	0.003	0.009	0.015	0.020	0.008
JAN 1993 - DEC 1993						
MEAN	0.00475	0.0030	0.0040	0.0150	0.0090	0.0080
MINIMUM VALUE	0.0035	0.003	0.004	0.015	0.009	0.008
MAXIMUM VALUE	0.0070	0.003	0.004	0.015	0.009	0.008
JAN 1994 - DEC 1994						
MEAN	0.00480	0.00250	0.00903	0.0290	0.0180	0.01203
MINIMUM VALUE	0.0048	0.0025	0.0087	0.029	0.018	0.0097
MAXIMUM VALUE	0.0048	0.0025	0.0100	0.029	0.018	0.0190

WILLIAMS OPERATING CORPORATION

SAMPLE SITE: M4-FRANK LAKE OUTLET

Date	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l	TOTAL ZINC mg/l
JAN 1987 - DEC 1987				
MEAN	0.0050	0.0348	0.0072	0.0132
MINIMUM VALUE	0.005	0.002	0.002	0.002
MAXIMUM VALUE	0.005	0.080	0.010	0.030
JAN 1988 - DEC 1988				
MEAN	0.0052	0.0238	0.012	0.0050
MINIMUM VALUE	0.005	0.012	0.01	0.003
MAXIMUM VALUE	0.006	0.043	0.02	0.008
JAN 1989 - DEC 1989				
MEAN	0.0050	0.0300	0.0118	0.0070
MINIMUM VALUE	0.005	0.021	0.005	0.006
MAXIMUM VALUE	0.005	0.049	0.018	0.008
JAN 1990 - DEC 1990				
MEAN	0.0065	0.017	0.0160	0.0080
MINIMUM VALUE	0.005	0.01	0.012	0.005
MAXIMUM VALUE	0.010	0.02	0.020	0.011
JAN 1991 - DEC 1991				
MEAN	0.0078	0.0200	0.0200	0.0130
MINIMUM VALUE	0.005	0.014	0.012	0.010
MAXIMUM VALUE	0.016	0.026	0.027	0.018
JAN 1992 - DEC 1992				
MEAN	0.0113	0.0392	0.0258	0.0085
MINIMUM VALUE	0.004	0.018	0.023	0.008
MAXIMUM VALUE	0.017	0.078	0.029	0.009
JAN 1993 - DEC 1993				
MEAN	0.0083	0.0352	0.0263	0.0083
MINIMUM VALUE	0.004	0.006	0.015	0.008
MAXIMUM VALUE	0.011	0.058	0.056	0.009
JAN 1994 - DEC 1994				
MEAN	0.01468	0.0715	0.0290	0.00970
MINIMUM VALUE	0.0087	0.023	0.029	0.0097
MAXIMUM VALUE	0.0190	0.121	0.029	0.0097

WILLIAMS OPERATING CORPORATION

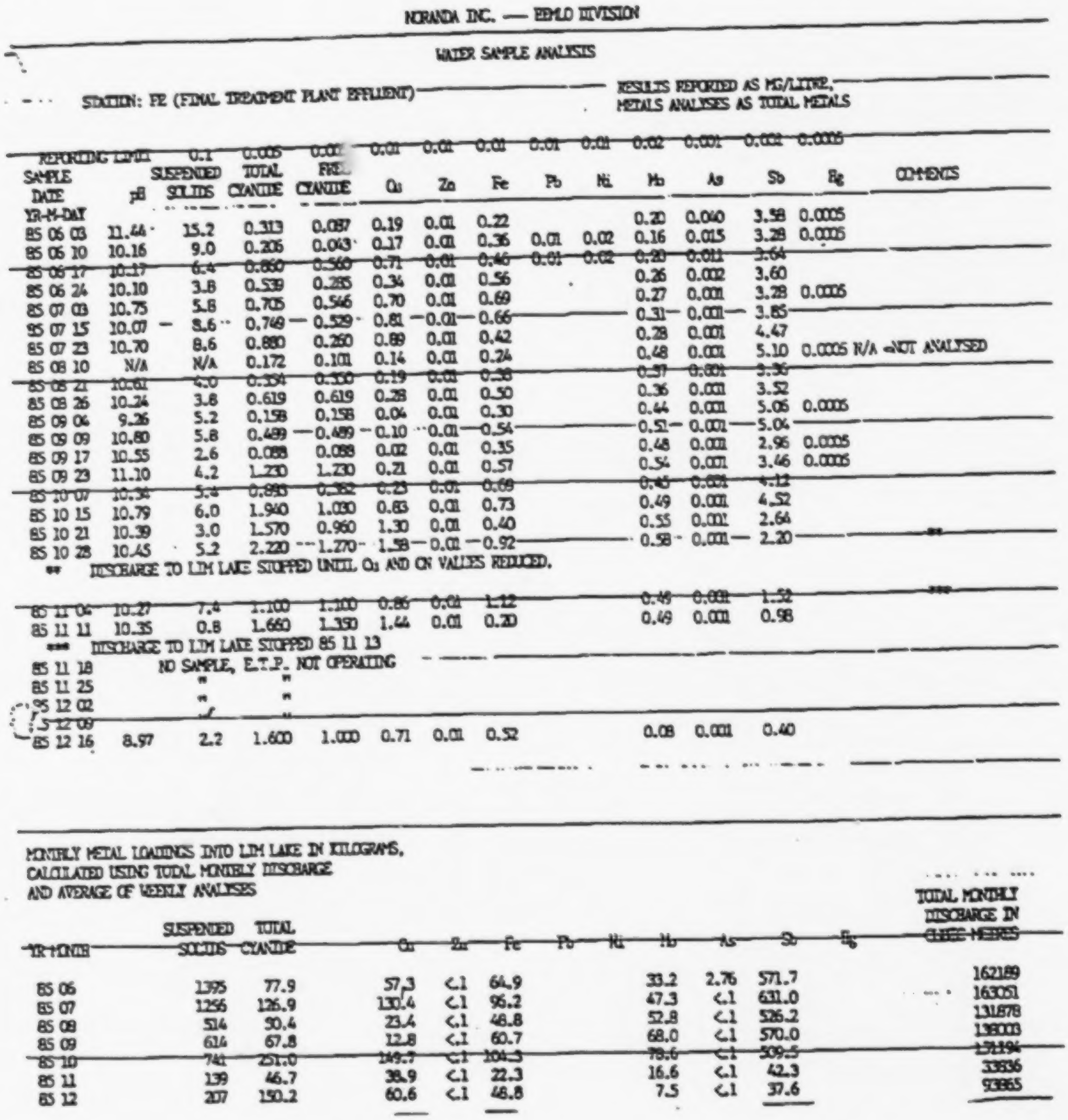
SAMPLE SITE: M6-WHITE RIVER UPSTREAM

Date	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l	TOTAL ZINC mg/l
JAN 1987 - DEC 1987				
MEAN	0.0050	0.0137	0.012	0.0035
MINIMUM VALUE	0.005	0.002	0.01	0.002
MAXIMUM VALUE	0.005	0.038	0.02	0.008
JAN 1988 - DEC 1988				
MEAN	0.0050	0.0068	0.015	0.0100
MINIMUM VALUE	0.005	0.003	0.01	0.002
MAXIMUM VALUE	0.005	0.010	0.02	0.032
JAN 1989 - DEC 1989				
MEAN	0.0050	0.0095	0.0075	0.0028
MINIMUM VALUE	0.005	0.002	0.001	0.002
MAXIMUM VALUE	0.005	0.016	0.010	0.005
JAN 1990 - DEC 1990				
MEAN	0.0050	0.010	0.0120	0.0050
MINIMUM VALUE	0.005	0.01	0.010	0.005
MAXIMUM VALUE	0.005	0.01	0.018	0.005
JAN 1991 - DEC 1991				
MEAN	0.0075	0.010	0.0153	0.0112
MINIMUM VALUE	0.005	0.01	0.010	0.005
MAXIMUM VALUE	0.015	0.01	0.027	0.030
JAN 1992 - DEC 1992				
MEAN	0.0093	0.0145	0.0150	0.0080
MINIMUM VALUE	0.004	0.009	0.015	0.008
MAXIMUM VALUE	0.015	0.031	0.015	0.008
JAN 1993 - DEC 1993				
MEAN	0.0040	0.0090	0.0155	0.0080
MINIMUM VALUE	0.004	0.009	0.015	0.008
MAXIMUM VALUE	0.004	0.009	0.017	0.008
JAN 1994 - DEC 1994				
MEAN	0.00928	0.0180	0.0290	0.01328
MINIMUM VALUE	0.0087	0.018	0.029	0.0097
MAXIMUM VALUE	0.0110	0.018	0.029	0.0240

WILLIAMS OPERATING CORPORATION

SAMPLE SITE: M7-WHITE RIVER DOWNSTREAM

Date	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL LEAD mg/l	TOTAL ZINC mg/l
JAN 1987 - DEC 1987				
MEAN	0.0050	0.0193	0.0152	0.0020
MINIMUM VALUE	0.005	0.002	0.010	0.002
MAXIMUM VALUE	0.005	0.048	0.021	0.002
JAN 1988 - DEC 1988				
MEAN	0.0050	0.0075	0.015	0.0028
MINIMUM VALUE	0.005	0.002	0.01	0.002
MAXIMUM VALUE	0.005	0.016	0.02	0.004
JAN 1989 - DEC 1989				
MEAN	0.0050	0.0073	0.0070	0.0025
MINIMUM VALUE	0.005	0.002	0.001	0.002
MAXIMUM VALUE	0.005	0.013	0.016	0.004
JAN 1990 - DEC 1990				
MEAN	0.0050	0.010	0.0110	0.0050
MINIMUM VALUE	0.005	0.01	0.010	0.005
MAXIMUM VALUE	0.005	0.01	0.014	0.005
JAN 1991 - DEC 1991				
MEAN	0.0070	0.010	0.0115	0.0088
MINIMUM VALUE	0.005	0.01	0.010	0.005
MAXIMUM VALUE	0.013	0.01	0.016	0.016
JAN 1992 - DEC 1992				
MEAN	0.0070	0.0117	0.0150	0.0080
MINIMUM VALUE	0.004	0.009	0.015	0.008
MAXIMUM VALUE	0.009	0.020	0.015	0.008
JAN 1993 - DEC 1993				
MEAN	0.0040	0.0090	0.0150	0.0080
MINIMUM VALUE	0.004	0.009	0.015	0.008
MAXIMUM VALUE	0.004	0.009	0.015	0.008
JAN 1994 - DEC 1994				
MEAN	0.00903	0.0180	0.0290	0.01203
MINIMUM VALUE	0.0087	0.018	0.029	0.0097
MAXIMUM VALUE	0.0100	0.018	0.029	0.0190



NORANDA INC. — HEMLO DIVISION

WATER SAMPLE ANALYSIS

STATION: FE (FINAL TREATMENT PLANT EFFLUENT)

RESULTS REPORTED AS MG/LITRE,
METALS ANALYSES AS TOTAL METALS

SAMPLE DATE YR-M-DAY	pH	SUSPENDED SOLIDS	TOTAL CYANIDE	FREE CYANIDE	Cu	Zn	Fe	Pb	Ni	Mn	As	Sb	Hg	COMMENTS
REPORTING LIMIT		0.1	0.005	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.001	0.002	0.0005	
85 06 03	11.44	15.2	0.313	0.087	0.19	0.01	0.22			0.20	0.040	3.58	0.0005	
85 06 10	10.16	9.0	0.206	0.043	0.17	0.01	0.36	0.01	0.02	0.16	0.015	3.28	0.0006	
~~85 06 17~~	~~10.17~~	~~6.4~~	~~0.860~~	~~0.560~~	~~0.71~~	~~0.01~~	~~0.46~~	~~0.01~~	~~0.02~~	~~0.20~~	~~0.011~~	~~3.64~~		
85 06 24	10.10	3.8	0.539	0.285	0.34	0.01	0.56			0.26	0.002	3.60		
85 07 03	10.75	5.8	0.705	0.546	0.70	0.01	0.69			0.27	0.001	3.28	0.0006	
85 07 15	10.07	8.6	0.749	0.529	0.81	0.01	0.66			0.31	0.001	3.85		
85 07 23	10.70	8.6	0.880	0.260	0.89	0.01	0.42			0.28	0.001	4.47		
85 08 10	N/A	N/A	0.172	0.101	0.14	0.01	0.24			0.48	0.001	5.10	0.0005	N/A =NOT ANALYSED
~~85 08 21~~	~~10.61~~	~~4.0~~	~~0.354~~	~~0.330~~	~~0.19~~	~~0.01~~	~~0.38~~			~~0.37~~	~~0.001~~	~~3.36~~		
85 08 26	10.24	3.8	0.619	0.619	0.28	0.01	0.50			0.36	0.001	3.52		
85 09 04	9.26	5.2	0.158	0.158	0.04	0.01	0.30			0.44	0.001	5.06	0.0006	
85 09 09	10.80	5.8	0.489	0.489	0.10	0.01	0.54			0.52	0.001	5.04		
85 09 17	10.55	2.6	0.088	0.088	0.02	0.01	0.35			0.48	0.001	2.96	0.0005	
85 09 23	11.10	4.2	1.230	1.230	0.21	0.01	0.57			0.54	0.001	3.46	0.0006	
~~85 10 07~~	~~10.34~~	~~5.4~~	~~0.893~~	~~0.382~~	~~0.23~~	~~0.01~~	~~0.69~~			~~0.45~~	~~0.001~~	~~4.12~~		
85 10 15	10.79	6.0	1.940	1.030	0.83	0.01	0.73			0.49	0.001	4.52		
85 10 21	10.39	3.0	1.570	0.960	1.30	0.01	0.40			0.55	0.001	2.64		
85 10 28	10.45	5.2	2.220	1.270	1.58	0.01	0.92			0.58	0.001	2.20		**
** DISCHARGE TO LIM LAKE STOPPED UNTIL Cu AND CN VALUES REDUCED.														
~~85 11 04~~	~~10.27~~	~~7.4~~	~~1.100~~	~~1.100~~	~~0.86~~	~~0.01~~	~~1.12~~			~~0.49~~	~~0.001~~	~~1.52~~		***
85 11 11	10.35	0.8	1.660	1.350	1.44	0.01	0.20			0.49	0.001	0.98		
*** DISCHARGE TO LIM LAKE STOPPED 85 11 13														
85 11 18		NO SAMPLE,	E.T.P. NOT OPERATING											
85 11 25		"	"											
85 12 02		"	"											
~~85 12 09~~			"											
85 12 16	8.97	2.2	1.600	1.000	0.71	0.01	0.52			0.08	0.001	0.40		

MONTHLY METAL LOADINGS INTO LIM LAKE IN KILOGRAMS,
CALCULATED USING TOTAL MONTHLY DISCHARGE
AND AVERAGE OF WEEKLY ANALYSES

YR-MONTH	SUSPENDED SOLIDS	TOTAL CYANIDE	Cu	Zn	Fe	Pb	Ni	Mn	As	Sb	Hg	TOTAL MONTHLY DISCHARGE IN CUBIC METRES
85 06	1395	77.9	57.3	<.1	64.9			33.2	2.76	571.7		162189
85 07	1256	126.9	130.4	<.1	96.2			47.3	<.1	631.0		163051
85 08	514	90.4	23.4	<.1	48.8			52.8	<.1	526.2		131878
85 09	614	67.8	12.8	<.1	60.7			68.0	<.1	570.0		138003
~~85 10~~	~~741~~	~~251.0~~	~~149.7~~	~~<.1~~	~~104.3~~			~~78.6~~	~~<.1~~	~~509.5~~		~~171194~~
85 11	139	46.7	38.9	<.1	22.3			16.6	<.1	42.3		33836
85 12	207	150.2	60.6	<.1	48.8			7.5	<.1	37.6		93865

NORANDA INC. — HEMLO DIVISION

WATER SAMPLE ANALYSIS

STATION: FE (FINAL TREATMENT PLANT EFFLUENT)

RESULTS REPORTED AS MG/LITRE,
METALS ANALYSES AS TOTAL METALS

SAMPLE DATE	pH	SUSPENDED SOLIDS	TOTAL CYANIDE	FREE CYANIDE	Cu	Zn	Fe	Pb	Ni	Mo	As	Sb	Hg	COMMENTS
REPORTING LIMIT:		0.1	0.005	0.005	0.01	0.01	0.01	0.01	0.01	0.02	0.001	0.001	0.0005	
YR MO DAY														
86 10 06	7.76		0.076	0.029									0.0005	GRAB SAMPLE
01/10 TO 07/10	7.99	3.2			0.06	0.01	0.34		0.78	0.96	0.001	4.40		WEEKLY COMPOSITE
86 10 14			0.79	0.44										GRAB SAMPLE
08/10 TO 14/10	8.04	4.0			0.09	0.01	0.46		0.79	1.00	0.001	4.30		WEEKLY COMPOSITE
86 10 20	7.99	9.6	0.32	0.049	0.08	0.01	0.23		1.12	1.00	0.001	4.60		GRAB SAMPLE
15/10 TO 22/10	8.04	2.8			0.09	0.01	0.15		1.23	0.96	0.001	3.90		WEEKLY COMPOSITE
23/10 TO 24/10	7.92	N/A			0.07	0.01	0.24		1.21	0.80	0.001	2.80		WEEKLY COMPOSITE
86 10 27	7.93	1.2	0.28	0.048	0.05	0.01	0.16		0.95	0.79	0.001	2.30		GRAB SAMPLE RECYCLED TO TAILINGS

NO EFFLUENT DISCHARGE EFFECTIVE OCT. 24/86

NOV. 1986 NO EFFLUENT DISCHARGE

DEC. 1986 NO EFFLUENT DISCHARGE

MONTHLY METAL LOADINGS INTO LUM LAKE IN KILOGRAMS.
CALCULATED USING TOTAL MONTHLY DISCHARGE
AND AVERAGE OF WEEKLY ANALYSES

YR MONTH	SUSPENDED SOLIDS	TOTAL CYANIDE	Cu	Zn	Fe	Pb	Ni	Mo	As	Sb	Hg	TOTAL MONTHLY DISCHARGE IN CUBIC METRES
86 01	740	121.0	70.6	<.1	166.2	—		77.7	<.1	509.4		180635
02	413	79.7	10.0	<.1	76.8	<.1	4.3	76.8	0.2	673.0	<.1	142276
86 03	152	90.9	8.0	<.1	38.3			98.7	0.1	829.9		144576
86 04	154	10.7	4.9	<.1	16.8			55.7	<.1	289.0		94122
86 05												NO DISCHARGE
86 06	119	12.3	2.2	<.1	11.9			35.2	<.1	183.9		62955
86 07	223	90.6	12.9	<.1	34.0		7.3	45.8	0.1	232.0		111792
86 08	328	26.9	16.8	<.1	95.2		14.6	58.8	<.1	423.6		135655
86 09	384	91.5	22.0	<.1	58.6		250.8	172.1	<.1	814.7		183069
86 10	523	57.6	12.2	<.1	46.8		157.0	146.0	<.1	604.4		156978
86 11												NO DISCHARGE
86 12												NO DISCHARGE

HEMLO GOLD MINES INC.

WATER SAMPLE ANALYSIS

STATION: FE (FINAL TREATMENT PLANT EFFLUENT)

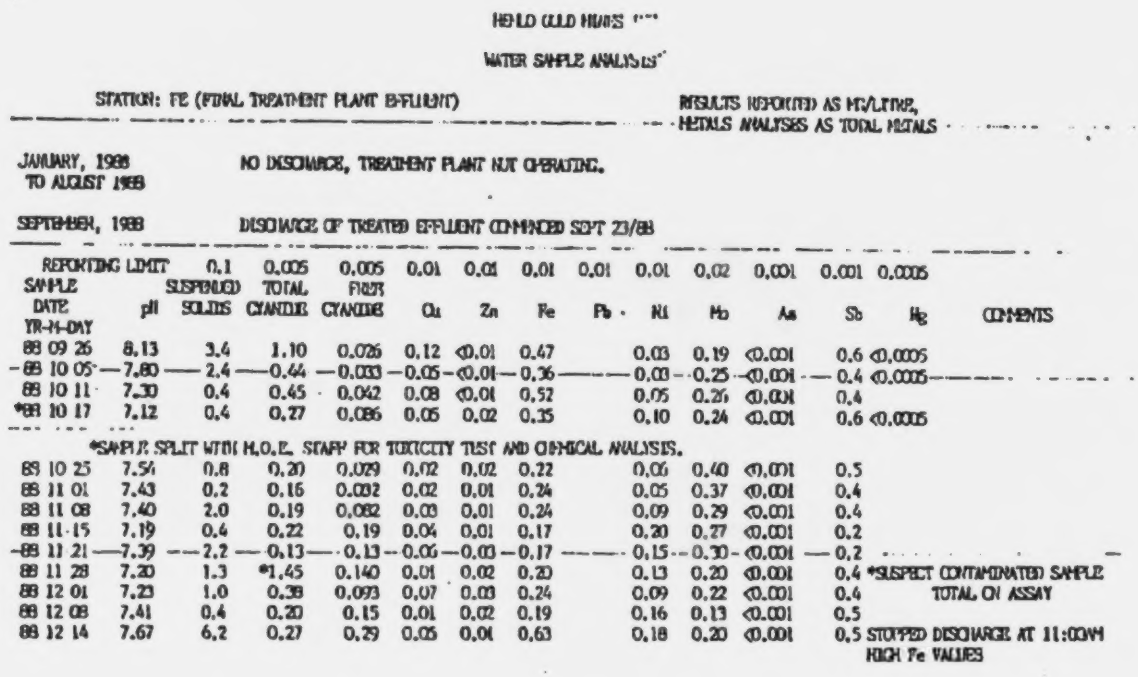
RESULTS REPORTED AS MG/LITRE,
METALS ANALYSES AS TOTAL METALS

JANUARY, 1987 NO DISCHARGE, TREATMENT PLANT NOT OPERATING
FEBRUARY, 1987 NO DISCHARGE, TREATMENT PLANT NOT OPERATING
MARCH, 1987 NO DISCHARGE, TREATMENT PLANT NOT OPERATING
APRIL, 1987 NO DISCHARGE, TREATMENT PLANT NOT OPERATING
MAY, 1987 NO DISCHARGE, TREATMENT PLANT NOT OPERATING
JUNE, 1987 NO DISCHARGE, TREATMENT PLANT NOT OPERATING

REPORTING LIMIT		0.1	0.005	0.005	0.01	0.01	0.01	0.01	0.01	0.02	0.001	0.001	0.0005	
SAMPLE DATE YR-M-DAY	pH	SUSPENDED SOLIDS	TOTAL CYANIDE	FREE CYANIDE	Cu	Zn	Fe	Pb	Ni	Mo	As	Sb	Hg	COMMENTS
87 07 08	9.61	0.2			0.79	0.02	0.19		0.10	0.60		1.0		
87 07 13	9.96	0.2	0.44	0.13	0.34	0.02	0.14		0.12	0.52	<.001	1.8	0.0012	
7 07 20	9.66	0.8	0.25	0.03	0.29	0.01	0.23		0.10	0.75	*	1.2		* SAMPLES LOST FOR As
87 07 27**	7.21	0.2	0.26	0.03	0.27	0.01	0.19		0.11	0.98	*	1.5		
** SAMPLE SPLIT WITH M.O.E. AND ZENON ENVIRONMENTAL FOR M.I.S.A. PRE-REGULATION MONITORING.														
87 08 05	8.09	1.6	0.50	0.14	0.50	0.01	0.52		0.05	0.86	<.001	2.7	0.0023	
87 08 10	7.62	1.8	0.29	0.07	0.35	0.01	0.14		0.05	0.87	<.001	3.3		
87 08 14	8.24	0.6	0.50	0.20	0.64	0.01	0.07		0.04	1.16	<.001	3.2		
87 08 24	8.05	0.2	1.31	1.15	2.06	0.01	0.12		0.04	0.70	0.001	3.6		NOT DISCHARGING
87 09 03	7.61	<0.1	0.13	0.068	0.25	0.01	0.11		0.06	0.82	<.001	3.1	0.0022	
87 09 10	7.42	0.4	0.32	0.078	0.78	0.01	0.11		0.15	1.48	<.001	3.7	0.0060	
87 09 14	7.46	0.2	0.25	0.046	0.22	0.01	0.14		0.06	0.60	<.001	3.4		
87 09 21	7.57	<0.1	0.38	0.13	0.32	0.01	0.14		0.06	0.46	<.001	3.0	0.0046	
87 09 29***	7.66	0.2	0.29	0.066	0.24	0.01	0.10		0.07	0.81	<.001	2.3	0.0061	
*** SAMPLE SPLIT WITH ZENON ENVIRONMENTAL FOR M.I.S.A. PRE-REGULATION MONITORING.														
87 10 01	7.40	<.1	0.24	0.022	0.30	0.01	0.06		0.05	0.96	<.001	3.2	0.0050	
87 10 08	6.48	<.1	0.37	0.13	1.60	0.01	0.11		0.24	0.74	<.001	3.7		NOT DISCHARGING
87 10 20	7.16	0.2	0.96	0.19	0.37	0.01	0.08		0.11	0.24	<.001	2.3	0.0046	
87 10 26	7.27	0.2	0.25	0.070	0.25	0.01	0.11		0.21	0.89	<.001	2.9	0.0023	
87 11 02	7.55	<.1	0.068	0.055	0.62	0.01	0.01		0.07	1.10	<.001	1.0	<0.0005	
87 11 09	7.29	<.1	0.38	0.086	0.69	0.01	0.08		0.19	1.00	<.001	3.3		
87 11 16	7.40	0.4	0.71	0.12	0.46	0.01	0.16		0.23	0.78	<.001	2.6		
87 11 23	9.99	6.0	0.34	0.19	0.81	0.02	0.09		0.25	0.64	<.001	1.9		
87 12 01	7.33	2.0	0.48	0.061	0.82	0.02	0.12		0.27	0.31	<.001	1.9	0.0055	

NO DISCHARGE EFFECTIVE DEC. 2/87

E.T.P. SHUT DOWN FOR WINTER SEASON.



HEMLO GOLD MINES

WATER SAMPLE ANALYSIS

STATION: FE (FINAL TREATMENT PLANT EFFLUENT)

RESULTS REPORTED AS MG/LITRE,
METALS ANALYSES AS TOTAL METALS

JANUARY, 1988 TO AUGUST 1988 — NO DISCHARGE, TREATMENT PLANT NOT OPERATING.

SEPTEMBER, 1988 — DISCHARGE OF TREATED EFFLUENT COMMENCED SEPT 23/88

REPORTING LIMIT		0.1	0.005	0.005	0.01	0.01	0.01	0.01	0.01	0.02	0.001	0.001	0.0005	
SAMPLE DATE YR-M-DAY	pH	SUSPENDED SOLIDS	TOTAL CYANIDE	FREE CYANIDE	Cu	Zn	Fe	Pb	Ni	Mo	As	Sb	Hg	COMMENTS
88 09 26	8.13	3.4	1.10	0.026	0.12	<0.01	0.47		0.03	0.19	<0.001	0.6	<0.0005	
88 10 05	7.80	2.4	0.44	0.033	0.05	<0.01	0.36		0.03	0.25	<0.001	0.4	<0.0005	
88 10 11	7.30	0.4	0.45	0.042	0.08	<0.01	0.52		0.05	0.26	<0.001	0.4		
*88 10 17	7.12	0.4	0.27	0.086	0.05	0.02	0.35		0.10	0.24	<0.001	0.6	<0.0005	

*SAMPLE SPLIT WITH M.O.E. STAFF FOR TOXICITY TEST AND CHEMICAL ANALYSIS.

SAMPLE DATE YR-M-DAY	pH	SUSPENDED SOLIDS	TOTAL CYANIDE	FREE CYANIDE	Cu	Zn	Fe	Pb	Ni	Mo	As	Sb	Hg	COMMENTS
88 10 25	7.54	0.8	0.20	0.029	0.02	0.02	0.22		0.06	0.40	<0.001	0.5		
88 11 01	7.43	0.2	0.16	0.032	0.02	0.01	0.24		0.05	0.37	<0.001	0.4		
88 11 08	7.40	2.0	0.19	0.082	0.03	0.01	0.24		0.09	0.29	<0.001	0.4		
88 11 15	7.19	0.4	0.22	0.19	0.04	0.01	0.17		0.20	0.27	<0.001	0.2		
88 11 21	7.39	2.2	0.13	0.13	0.06	0.03	0.17		0.15	0.30	<0.001	0.2		
88 11 28	7.20	1.3	*1.45	0.140	0.01	0.02	0.20		0.13	0.20	<0.001	0.4		*SUSPECT CONTAMINATED SAMPLE
88 12 01	7.23	1.0	0.38	0.093	0.07	0.03	0.24		0.09	0.22	<0.001	0.4		TOTAL CN ASSAY
88 12 08	7.41	0.4	0.20	0.15	0.01	0.02	0.19		0.16	0.13	<0.001	0.5		
88 12 14	7.67	6.2	0.27	0.29	0.05	0.01	0.63		0.18	0.20	<0.001	0.5		STOPPED DISCHARGE AT 11:00AM HIGH Fe VALUES

HEMLO GOLD MINES INC.

WATER SAMPLE ANALYSIS

FE (FINAL TREATMENT PLANT EFFLUENT)

RESULTS REPORTED AS MG/LITRE,
METALS ANALYSES AS TOTAL METALS

SAMPLE DATE	pH	SUSP SOLIDS	TOTAL CN	FREE CN	Cu	Zn	Fe	Pb	Ni	Mo	As	Sb	Hg	FLOW M^3/mo
5-Jan-89	7.58	1.4	0.740	0.57	0.10	0.14	0.63		0.29	0.30	<0.001	0.300	<0.0005	
10-Jan-89	7.49	0.2	0.490	0.37	0.07	0.02	0.22		0.37	0.38	<0.001	0.500		
16-Jan-89	7.43	1.2	0.200	0.066	0.04	0.02	0.27		0.08	0.34	<0.001	0.500		157,846
1-Feb-89	7.52	1.6	0.420	0.35	0.03	0.03	0.28		0.20	0.40	<0.001	0.500	<.0005	
6-Feb-89	7.35	4.0	0.670	0.41	0.04	0.02	1.01		0.21	0.31	<0.001	0.500		
13-Feb-89	7.51	1.6	0.740	0.30	0.01	0.01	0.22		0.13	0.65	<0.001	0.500		
20-Feb-89	7.55	0.4	0.830	0.49	0.01	0.01	0.24		0.23	0.31	<0.001	0.500		169,537
1-Mar-89	7.41	0.4	1.100	0.64	0.02	0.02	0.27		0.24	0.18	<0.001	0.400	<.0005	
6-Mar-89	7.18	1.2	1.002	0.86	0.04	0.02	0.22		0.32	0.15	<0.001	0.500		
7-Mar-89	7.12	0.6	1.093 *	0.75	0.03	0.02	0.21		0.27	0.16	<0.001	0.500		
13-Mar-89	7.21	1.0	0.330	0.20	0.03	0.01	0.14		0.08	0.23	<0.001	0.400		
20-Mar-89	7.11	0.4	0.464	0.16	0.04	0.01	0.10		0.11	0.22	<0.001	0.300		196,942
3-Apr-89	7.38	1.8	0.096	0.14	0.03	0.01	0.11		0.05	0.46	<0.001	0.600	<.0005	
10-Apr-89	7.36	0.6	0.486	<0.005	0.06	0.01	0.16		0.08	0.45	<0.001	0.400		
17-Apr-89	7.32	0.8	0.154	0.135	0.10	0.01	0.26		0.15	0.55	<0.001	0.400		
18-Apr-89	7.32	1.2	0.831	0.187	0.11	0.01	0.25		0.15	0.59	<0.001	0.400		
24-Apr-89	7.25	2.2	0.730	0.486	0.13	0.02	0.24		0.22	0.45	<0.001	0.400		191,861
1-May-89	7.38	1.2	0.408	0.252	0.14	0.02	0.31		0.23	0.50	<0.001	0.400	<.0005	
8-May-89	7.23	0.4	0.059	0.054	0.09	0.02	0.20		0.16	0.51	<0.001	0.200		
16-May-89	7.31	1.2	0.083	0.027	0.06	0.01	0.21		0.13	0.44	<0.001	0.300		
23-May-89	7.61	2.4	0.288	0.093	0.05	<0.01	0.41		0.13	0.79	<0.001	0.300		199,801
5-Jun-89	7.64	2.4	0.370		0.11	0.02	0.25		0.24	0.37	<0.001	0.300	<.0005	
10-Jun-89	7.42	1.4	0.139	<0.005	0.07	0.01	0.29		0.18	0.45	<0.001	0.400		
19-Jun-89	7.65	2.8	0.026	0.005	0.50	0.01	0.16		0.14	0.45	<0.001	0.500		
26-Jun-89	7.79	3.6	0.020	<0.005	0.05	0.01	0.17		0.09	0.61	<0.001	~~0.500~~		179,425
3-Jul-89	7.79	3.2	0.028	0.006	0.02	0.01	0.49		0.10	0.71	<0.001	0.300	<.0005	
10-Jul-89	7.79	3.6	0.029	<0.005	0.02	0.01	0.04		0.09	0.76	<0.001	0.300		
17-Jul-89	7.68	0.4	0.022	<0.005	0.02	0.02	0.17		0.05	0.68	<0.001	0.300		
18-Jul-89	7.69	0.6	0.027	<0.005	0.01	0.02	0.16		0.06	0.61	<0.001	0.300		
24-Jul-89	7.75	2.0	0.037	<0.005	0.02	0.02	0.21		0.06	0.37	<0.001	0.300		188,456
1-Aug-89	7.30	2.0	0.032	<0.005	0.06	0.05	0.15		0.39	0.07	<0.001	0.400	<.0005	
8-Aug-89	7.44	1.8	0.050	<0.005	0.04	0.01	0.24		0.07	0.21	<0.001	0.300		
14-Aug-89	7.63	1.6	0.029	<0.005	0.04	0.02	0.09		0.06	0.43	<0.001	0.400		
23-Aug-89	7.48	1.6	0.035	<0.005	0.03	0.02	0.12		0.02	0.18	<0.001	1.200		185,656
1-Sep-89	7.43	1.6	0.069	0.007	0.02	0.02	0.28		0.03	0.30	<0.001	0.400	<.0005	
11-Sep-89	7.50	1.8	0.035	<0.005	0.01	0.03	0.22		0.04	0.33	<0.001	0.400		
18-Sep-89	7.34	1.6	0.067	<0.005	0.02	0.01	0.23		0.08	0.20	<0.001	0.320		
25-Sep-89	7.57	1.8	0.035	0.005	0.04	0.02	0.46		0.04	0.23	<0.001	0.600		157,202
2-Oct-89	7.42	1.4	0.089	0.027	0.01	0.01	0.20		0.12	0.26	<0.001	0.400	<.0005	
10-Oct-89	7.42	1.8	0.195	0.015	<0.01	<0.01	0.21		0.07	0.15	<0.001	0.300		
17-Oct-89	7.37	1.8	0.121	0.015	0.04	<0.01	0.26		0.14	0.11	0.001	0.330		
23-Oct-89	7.33	2.0	0.207	0.028	0.05	<0.01	0.31		0.11	0.22	0.001	0.500		166,421
2-Nov-89	7.65	1.0	0.363	0.122	0.04	<0.01	0.31	<.01	0.19	0.12	<0.002	0.146	<.0005	
13-Nov-89	7.51	1.4	0.296	0.098	0.05	<0.01	0.27		0.18	0.17	<0.002	0.108		
21-Nov-89	7.39	0.2	0.380	0.198	0.05	<0.01	0.29		0.10	0.16	<0.002	0.237		
27-Nov-89	7.03	0.6	1.800	0.285	0.06	<0.01	0.23		0.14	0.21	<0.002	0.320		
28-Nov-89	7.35	0.4	1.570	1.020	0.07	<0.01	0.29		0.18	0.20	<0.002	0.231		155,273

HEMLO GOLD MINES INC.
GOLDEN GIANT MINE

WATER SAMPLE ANALYSIS

STATION: FE (FINAL EFFLUENT)

Results reported as mg/L
Metals analyses as total metals

		0.1	0.005	0.005	0.01	0.01	0.02	0.01	0.01	0.002	0.002	0.0005	0.05	
SAMPLE DATE	pH	SUSPENDED SOLIDS	TOTAL CYANIDE	FREE CYANIDE	Cu	Zn	Ni	Fe	Mo	As	Sb	Hg	Pb	FLOW WK AVG (m3/DAY)
Jan-90		NO DISCHARGE TO LIM LAKE												
Feb-90		NO DISCHARGE TO LIM LAKE												
Mar-90		NO DISCHARGE TO LIM LAKE												
Apr-90		NO DISCHARGE TO LIM LAKE												
May-90		NO DISCHARGE TO LIM LAKE												
Jun-90		NO DISCHARGE TO LIM LAKE												
17-Jul-90	7.59	6.2	0.136	0.005	0.09	<0.01	0.03	0.95	0.05	<0.002	0.390	<0.002	<0.05	5903.5
09-Aug-90	8.10	4.6	0.105	<0.005	0.02	<0.01	0.02	0.75	0.67	<0.002	0.370	<0.0005	<0.05	2065.9
16-Aug-90	7.73	4.8	0.046	0.010	0.04	<0.01	<0.02	0.67	0.88	0.0012	0.271		<0.05	3928.4
20-Aug-90	7.79	4.2	0.074	0.007	0.05	<0.01	<0.02	0.60	0.89	0.0015	0.223		<0.05	4622.5
27-Aug-90	7.69	2.8	0.017	<0.005	0.02	<0.01	0.02	0.27	0.89	<0.002	0.190		<0.05	5083.6
04-Sep-90	7.71	3.2	<0.005	<0.005	0.01	<0.01	<0.02	0.28	0.59	<0.002	0.153	<0.0005	<0.05	4175.1
10-Sep-90	7.86	9.8	0.060	0.010	0.04	<0.01	0.06	0.70	0.56	<0.002	0.168		<0.05	5064.3
17-Sep-90	7.76	3.6	0.039	0.015	0.05	0.03	0.05	1.04	0.65	0.0022	0.359	<0.0005	<0.05	4915.3
24-Sep-90	7.71	2.0	0.035	0.006	0.05	<0.01	0.04	0.54	0.39	<0.002	0.166		<0.05	4669.1
01-Oct-90	7.84	1.2	0.072	0.016	0.03	<0.01	0.07	0.20	0.34	<0.002	0.377	<0.0005	<0.05	4849.6
09-Oct-90	7.61	1.0	0.052	0.021	0.035	<0.01	0.08	0.04	0.34	<0.002	0.408		<0.05	5406.1
15-Oct-90	7.33	2.6	0.045	0.014	0.040	<0.01	0.08	0.04	0.36	<0.002	0.316		<0.05	6204.2
22-Oct-90	7.41	0.2	0.040	0.015	0.042	<0.01	0.05	0.04	0.48	<0.002	0.382		<0.05	5438.0
29-Oct-90	7.67	1.0	0.062	0.015	0.027	<0.01	0.07	0.05	0.40	<0.002	0.361		<0.05	6251.3
05-Nov-90	7.69	0.4	0.049	0.017	0.049	<0.01	0.10	0.03	0.48	<0.002	0.322	<0.0005	<0.05	6016.0
12-Nov-90	7.70	0.8	0.017	0.007	0.035	<0.01	0.09	0.04	0.41	<0.002	0.596		<0.05	6070.4
19-Nov-90	7.88	2.0	0.056	0.014	0.021	<0.01	<0.02	0.01	<0.01	<0.002	0.589		<0.05	6024.7
26-Nov-90	7.60	3.0	0.040	0.014	0.026	<0.01	0.07	0.10	0.81	<0.002	0.604		<0.05	5970.3
04-Dec-90	7.62	3.8	0.078	0.016	0.035	0.03	0.12	0.10	0.66	0.002	0.660	<0.0005	<0.05	4684.5
10-Dec-90	7.78	2.6	0.113	0.027	0.031	<0.01	0.08	0.04	0.73	<0.002	0.456	<0.0005	<0.05	5850.3
17-Dec-90	7.75	1.2	0.084	0.044	0.051	0.01	0.10	0.04	0.75	<0.002	0.413		<0.05	5779.1
24-Dec-90	7.34	2.0	0.149	0.119	0.062	0.02	0.14	0.64	0.62	<0.002	0.370		<0.05	5725.6
31-Dec-90	8.36	1.4	0.319	0.231	0.045	<0.01	0.12	0.54	1.69	0.003	0.392		<0.05	5176.0

HEMLO GOLD MINES INC.
GOLDEN GIANT MINE

WATER SAMPLE ANALYSIS

STATION: FE (FINAL EFFLUENT)

Results reported as mg/L
Metals analyses as total metals

SAMPLE DATE	pH	TSS	TOTAL CYANIDE	FREE CYANIDE	Cu	Zn	Ni	Fe	Mo	As	Sb	Hg	Pb	DAILY FLOW (m3)
REPORTING LIMIT:		1.0	0.005	0.005	0.006	0.01	0.02	0.01	0.01	0.002	0.002	0.0005	0.05	
08-Jan-91	7.78	<1.0	0.310	0.113	0.048	<0.01	0.14	0.73	0.57	<0.002	0.413	<0.0005	<0.05	3545
14-Jan-91	7.64	<1.0	0.113	0.174	0.056	0.01	0.13	0.83	0.26	0.018	0.534	<0.0005	<0.05	5291
		Stopped discharging on 19-Jan-91												4781
Feb-91		No Discharge to Lim Lake												
Mar-91		No Discharge to Lim Lake												
		Started Discharging on 12-Apr-91												
15-Apr-91	7.55	3.8	0.061	0.032	0.119	0.01	0.22	0.54	0.38	0.003	0.200	<0.0005	<0.05	5479
23-Apr-91	7.49	1.8	0.159	0.008	0.257	0.01	0.22	0.34	0.28	<0.002	0.101		<0.05	6484
29-Apr-91	7.51	1.8	0.156	0.086	0.088	0.01	0.19	0.25	0.83	0.002	0.153		<0.05	5285
06-May-91	7.52	<1.0	0.204	0.101	0.071	0.01	0.15	0.16	0.68	<0.002	0.279		<0.05	4303
13-May-91	7.73	<1.0	0.185	<0.005	0.050	<0.01	0.17	0.15	0.80	<0.002	0.331		<0.05	6252
21-May-91	7.78	3.8	0.184	0.031	0.035	<0.01	0.18	0.35	0.70	<0.002	0.294	<0.0005	<0.05	6127
27-May-91	7.88	1.8	0.080	0.014	0.024	0.01	0.11	0.19	0.78	<0.002	0.217	<0.0005	<0.05	6929
04-Jun-91	7.80	1.2	0.048	0.008	0.028	<0.01	0.15	0.19	0.51	<0.002	0.205		<0.05	6536
		Stopped discharging on 08-Jun-91												
MEAN	7.67	1.7	0.147	0.057	0.079	0.01	0.17	0.37	0.58	0.004	0.279	<0.0005	<0.05	5800
MAXIMUM	7.88	3.8	0.310	0.174	0.257	0.01	0.22	0.83	0.83	0.018	0.534	<0.0005	<0.05	6484
MINIMUM	7.49	<1.0	0.048	<0.005	0.024	<0.01	0.11	0.15	0.26	<0.002	0.101	<0.0005	<0.05	3545

HEMLO GOLD MINES INC.
GOLDEN GIANT MINE

WATER MONITORING PROGRAM

Final Effluent

Sample Date	pH	TSS	Total Cyanide	Free Cyanide	Cu	Zn	Ni	Fe	Mo	As	Sb	Hg	Pb
25-May-92	7.51	<1	0.054	0.041	0.124	0.01	0.15	0.29	0.18	<0.002	0.116	<0.0001	<0.05
01-Jun-92	7.43	1	0.078		0.139	0.01	0.19	0.20	0.14	<0.002	0.066	<0.0001	0.06
08-Jun-92	7.80	<1	0.077	0.087	0.077	0.01	0.11	0.96	0.33	0.003	0.089		<0.05
15-Jun-92	7.57	1	0.179	0.089	0.063	0.02	0.19	0.18	0.38	<0.002	0.283		0.05
22-Jun-92	7.48	<1	0.110	0.025	0.065	0.02	0.19	0.31	0.35	<0.002	0.724		<0.05
28-Jun-92	7.57	2	0.027	0.016	0.082	0.01	0.18	0.27	0.39	<0.002	0.554		<0.05
06-Jul-92	7.61	<1	0.013	<0.005	0.040	<0.01	0.10	0.23	0.30	<0.002	0.210		<0.05
13-Jul-92	7.72	2	0.014	<0.005	0.042	<0.01	0.06	0.28	0.47	<0.002	0.304		<0.05
20-Jul-92	7.68	1	0.009	<0.005	0.039	<0.01	0.05	0.24	0.47	<0.002	0.570	<0.0001	<0.05
27-Jul-92	7.80	4	0.024	<0.005	0.077	<0.01	0.05	0.89	0.39	<0.002	0.897		<0.05
04-Aug-92	7.63	2	0.188	0.018	0.063	0.02	0.06	0.77	0.23	0.002	0.485		<0.05
10-Aug-92	7.60	1	0.011	<0.005	0.059	<0.01	0.07	0.30	0.13	<0.002	0.128		0.10
17-Aug-92	7.59	<1	0.028	<0.005	0.042	<0.01	0.04	0.41	0.20	0.002	0.328	<0.0001	<0.05
24-Aug-92	7.49	2	0.048	0.008	0.038	<0.01	0.03	0.56	0.28	0.002	0.391		0.05
31-Aug-92	7.49	<1	<0.005	<0.005	0.038	<0.01	0.03	0.47	0.16	<0.002	0.208		<0.05
08-Sep-92	7.40	<1	0.050	<0.005	0.043	0.01	0.05	0.32	0.10	<0.002	0.073	<0.0001	<0.05
14-Sep-92	7.27	<1	0.058	0.013	0.032	<0.01	0.05	0.37	0.08	<0.002	0.154		<0.05
29-Sep-92	7.42	2	0.022	0.008	0.041	0.01	0.16	0.10	0.15	<0.002	0.134		<0.05
04-Oct-92	7.34	1	0.045	0.018	0.069	0.01	0.09	0.57	0.12	<0.002	0.223		0.15
13-Oct-92	7.49	<1	0.062	0.013	0.033	<0.01	0.03	0.68	0.18	<0.002	0.120		<0.05
20-Oct-92	7.51	1	0.088	0.055	0.070	<0.01	0.07	0.41	0.20	<0.002	0.068		0.16
25-Oct-92	7.39	1	0.178	0.074	0.030	<0.01	0.06	0.38	0.09	<0.002	0.108		<0.05
04-Nov-92	7.41	1	0.209	0.142	0.022	0.01	0.09	0.40	0.07	<0.002	0.072		<0.05
09-Nov-92	7.56	<1	0.233	0.195	0.032	0.01	0.10	0.33	0.13	<0.002	0.083		<0.05
16-Nov-92	7.28	2	0.397	0.303	0.072	0.01	0.14	0.50	0.17	<0.002	0.121		0.16
23-Nov-92	7.29	<1	0.158	0.117	0.139	0.01	0.09	0.34	0.17	<0.002	0.228		0.16
30-Nov-92	7.47	1	0.144	0.108	0.117	0.01	0.08	0.43	0.29	<0.002	0.244		0.15
07-Dec-92	7.14	<1	0.108	0.101	0.138	0.02	0.11	0.57	0.09	<0.002	0.277		<0.05
14-Dec-92	7.16	1	0.147	0.091	0.101	0.01	0.10	0.45	0.18	<0.002	0.269	<0.0001	0.06
21-Dec-92	7.44	2	0.124	0.078	0.083	0.01	0.12	0.44	0.16	<0.002	0.078		0.11
28-Dec-92	7.25	2	0.153	0.101	0.162	0.04	0.18	0.61	0.16	<0.002	0.125		0.32
MEAN	7.47	1	0.097	0.058	0.069	0.01	0.10	0.42	0.22	0.000	0.249	<0.0001	0.06
STD.DEV.	0.16	1	0.086	0.088	0.039	0.01	0.05	0.19	0.11	0.001	0.201	0	0.08

HEMLO GOLD MINES INC.
GOLDEN GIANT MINE

WATER MONITORING PROGRAM

Final Effluent (FE)

Sample Date	pH	TSS	Total Cyanide	Free Cyanide	Cu	Zn	Ni	Fe	Mo	As	Sb	Hg	Pb
Detection Limits		1	0.005	0.005	0.01	0.01	0.02	0.02	0.02	0.002	0.002	0.0001	0.03
4-Jan-93	7.15	1	0.174	0.122	0.14	0.01	0.12	0.53	0.15	<0.002	0.138	<0.0001	0.09
11-Jan-93	7.23	6	0.215	0.149	0.27	0.03	0.14	0.87	0.16	<0.002	0.246		0.10
18-Jan-93	7.31	1	0.115	0.076	0.18	0.02	0.10	0.50	0.19	<0.002	0.074		0.10
25-Jan-93	7.06	3	0.189	0.146	0.19	0.02	0.09	0.57	0.19	<0.002	0.063		0.07
1-Feb-93	7.16	2	0.313	0.272	0.30	0.01	0.07	0.62	0.21	<0.002	0.225		0.06
8-Feb-93	7.28	1	0.578	0.374	0.50	0.03	0.12	0.57	0.36	<0.002	0.179		0.35
15-Feb-93	7.02	2	0.507	0.336	0.34	<0.01	0.04	0.61	0.17	<0.002	0.224		<0.05
22-Feb-93	7.08	1	0.238	0.155	0.32	0.01	0.10	0.50	0.20	<0.002	0.069		0.08
1-Mar-93	7.48	2	0.389	0.336	0.27	<0.01	0.09	0.36	0.26	<0.002	0.130	<0.0001	0.05
8-Mar-93	7.21	2	0.307	0.146	0.23	0.01	0.09	0.28	0.22	<0.002	0.135		0.07
15-Mar-93	7.12	1	0.456	0.238	0.44	0.02	0.12	0.30	0.19	<0.002	0.098		0.12
22-Mar-93	7.30	2	0.201	0.118	0.17	<0.01	0.14	0.37	0.20	<0.002	0.065		<0.05
29-Mar-93	7.37	<1	0.216	0.120	0.11	<0.01	0.06	0.28	0.22	<0.002	0.089		<0.05
5-Apr-93	7.42	<1	0.134	0.123	0.12	<0.01	0.07	0.34	0.30	<0.002	0.133	<0.0001	<0.05
3-Sep-93	7.25				0.02		0.03	0.90	0.42		0.300		
8-Sep-93	7.54				0.05		0.03	0.90	0.49		0.500		
17-Sep-93	7.71				0.03		0.02	0.92	0.23		0.600		
20-Sep-93	7.70				0.01		<0.02	0.94	0.14		0.200		
28-Sep-93	6.13	3	0.013	0.007	0.01	0.02	0.02	0.86	0.13	0.002	0.801		<0.03
4-Oct-93	7.08	<1	0.065	0.020	0.01	<0.01	<0.02	0.78	0.11	0.003	0.544	<0.0001	<0.03
12-Oct-93	6.08	5	0.041	0.014	0.01	0.02	<0.02	0.97	0.12	0.002	0.353		<0.03
27-Oct-93	7.42				0.02		0.09	0.30	0.17		0.700		
1-Nov-93	7.35	1	0.143	0.088	<0.01	0.02	0.08	0.11	0.10	<0.002	0.298	<0.0001	<0.03
8-Nov-93	6.51	1	0.277	0.227	0.01	0.01	0.12	0.44	0.10	0.002	0.439		<0.03
15-Nov-93	6.74	2	0.305	0.256	0.01	0.01	0.12	0.29	0.19	<0.002	0.608		<0.03
22-Nov-93	7.44	1	0.392	0.320	0.02	0.02	0.13	0.51	0.28	0.002	0.706		<0.03
29-Nov-93	7.30	<1	0.560	0.530	0.05	0.01	0.14	0.18	0.23	<0.002	0.617		<0.03
6-Dec-93	7.66	1	0.608	0.551	0.26	0.01	0.13	0.22	0.24	<0.002	0.678	<0.0001	<0.03
13-Dec-93	7.26	<1	0.765	0.660	0.25	0.01	0.15	0.20	0.27	<0.002	0.709		<0.03
20-Dec-93	7.05	<1	1.020	0.900	0.55	0.01	0.12	0.21	0.34	<0.002	0.638		<0.03
28-Dec-93	6.48	<1	0.698	0.600	0.68	0.01	0.10	0.20	0.31	<0.002	0.610		<0.03

Parameters Reported in mg/L and Total Metals

HEMLO GOLD MINES INC.
GOLDEN GIANT MINE

WATER MONITORING PROGRAM

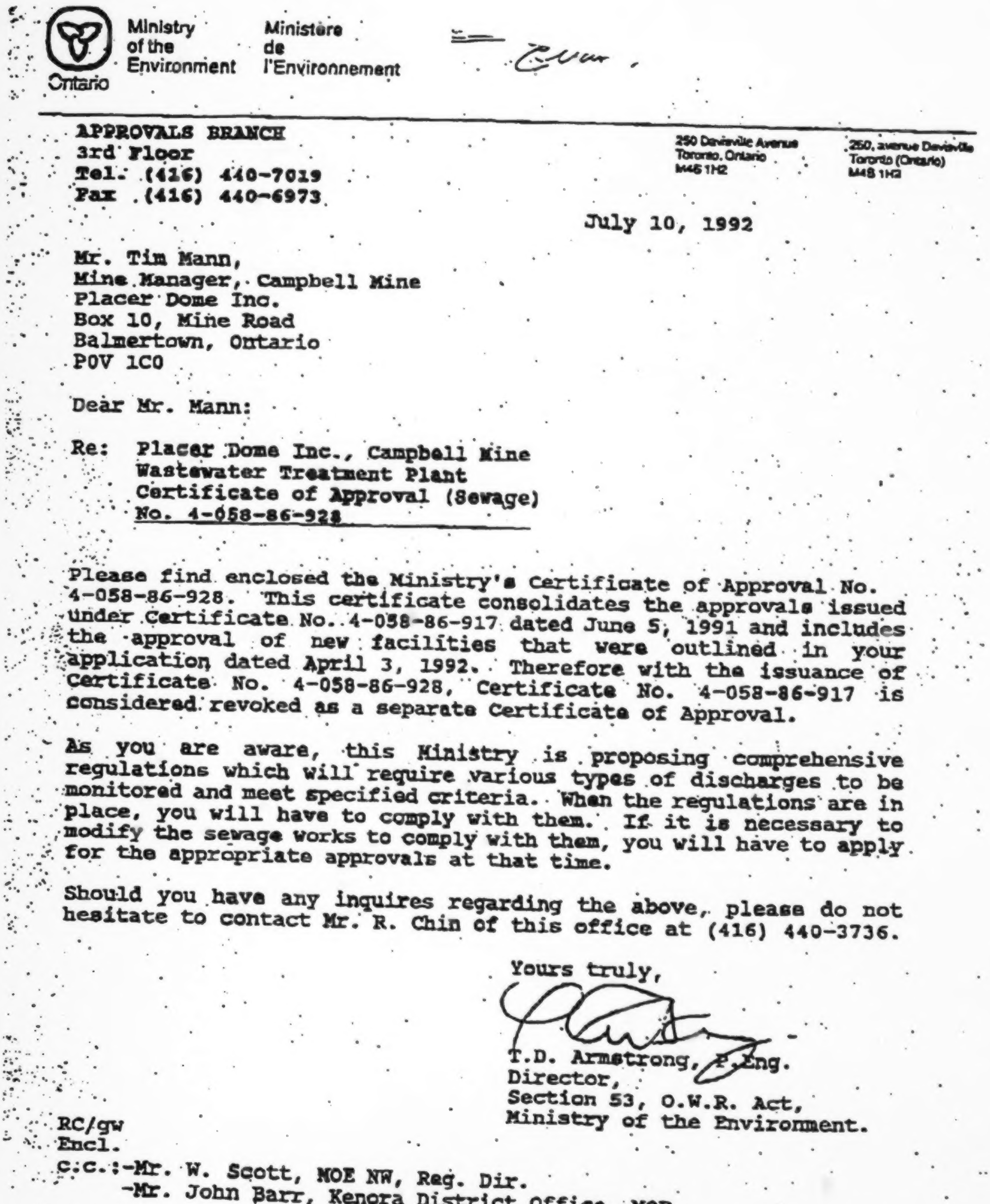
Final Effluent (FE)

Sample Date	pH	TSS	Total Cyanide	Free Cyanide	Cu	Zn	Ni	Fe	Mo	As	Sb	Hg	Pb
Detection Limits:		1	0.005	0.005	0.01	0.01	0.02	0.01	0.02	0.002	0.002	0.0001	0.03
03-Jan-94	6.92	2	1.102	1.030	0.81	0.02	0.11	0.33	0.31	<0.002	0.799	<0.0001	<0.03
10-Jan-94	7.58	<1	1.340	1.205	1.01	<0.01	0.11	0.32	0.90	<0.002	0.694		<0.03
17-Jan-94	No Discharge												
24-Jan-94	6.48	1	0.090	0.042	<0.01	<0.01	0.02	0.34	0.36	<0.002	0.259		<0.03
31-Jan-94	6.99	<1	0.440	0.345	0.32	<0.01	0.05	0.25	0.54	<0.002	0.254		<0.03
07-Feb-94	6.50	1	0.505	0.425	0.30	<0.01	0.10	0.23	0.51	<0.002	0.301	<0.0001	<0.03
14-Feb-94	7.00	2	0.668	0.546	0.21	<0.01	0.13	0.23	0.63	<0.002	0.293		<0.03
21-Feb-94	7.29	<1	0.620	0.460	0.32	<0.01	0.07	0.21	0.65	0.002	0.232		<0.03
28-Feb-94	6.72	2	1.070	0.640	0.69	0.01	0.05	0.34	0.56	<0.002	0.261		<0.03
09-Mar-94	7.09	2	0.435	0.403	0.27	<0.01	0.08	0.36	0.65	<0.002	0.241	<0.0001	<0.03
15-Mar-94	7.09	1	0.590	0.275	0.49	<0.01	0.07	0.12	0.59	<0.002	0.250		<0.03
21-Mar-94	6.78	2	0.828	0.389	0.07	0.01	0.09	0.48	0.83	<0.002	0.381		<0.03
28-Mar-94	6.65	2	0.844	0.397	0.06	<0.01	0.07	0.39	0.66	<0.002	0.550		<0.03
04-Apr-94	7.21	<1	0.935	0.465	0.09	<0.01	0.11	0.74	0.63	<0.002	0.570	<0.0001	<0.03
11-Apr-94	6.99	<1	0.990	0.460	0.12	<0.01	0.10	0.57	0.31	0.002	0.385		<0.03
18-Apr-94	7.09	1	0.556	0.298	0.09	0.01	0.07	0.52	0.17	<0.002	0.208		<0.03
25-Apr-94	6.86	<1	0.450	0.280	0.08	0.02	0.09	0.36	0.20	<0.002	0.163		<0.03
02-May-94	6.23	<1	0.970	0.690	0.18	0.01	0.17	0.26	0.20	<0.002	0.231	0.0001	<0.03
09-May-94	6.27	1	0.162	0.071	0.03	0.01	0.08	0.25	0.10	<0.002	0.175		<0.03
16-May-94	6.89	<1	0.385	0.190	0.04	0.01	0.10	0.23	0.17	<0.002	0.230		<0.03
24-May-94	6.23	<1	0.235	0.059	0.03	<0.01	0.10	0.15	0.31	<0.002	0.215		<0.03
30-May-94	6.85	<1	0.071	0.029	0.01	<0.01	0.09	0.15	0.37	<0.002	0.086		<0.03
06-Jun-94	6.87	<1	0.290	0.052	0.01	<0.01	0.10	0.07	0.40	<0.002	0.105	<0.0001	<0.03
13-Jun-94	6.68	<1	0.275	0.024	<0.01	<0.01	0.05	0.05	0.43	<0.002	0.092		<0.03
20-Jun-94	Plant Shut Down												
27-Jun-94	No Discharge												
04-Jul-94	6.92	1	0.160	0.007	0.01	<0.01	0.03	0.08	0.22	<0.002	0.100	<0.0001	<0.03
11-Jul-94	7.07	<1	0.126	0.005	0.01	0.01	0.05	0.10	0.34	<0.002	0.094		<0.03
18-Jul-94	7.28	1	0.236	0.008	<0.01	<0.01	0.03	0.08	0.48	<0.002	0.072		<0.03
25-Jul-94	7.25	<1	0.081	0.011	<0.01	<0.01	0.06	0.05	0.54	<0.002	0.143		<0.03
02-Aug-94	7.17	<1	0.047	0.009	0.04	0.03	0.05	0.06	0.43	<0.002	0.064	<0.0001	<0.03
08-Aug-94	Plant Shut Down												
15-Aug-94	No Discharge												
22-Aug-94	6.85	1	0.048	0.007	<0.01	<0.01	0.03	0.13	0.27	<0.002	0.075		<0.03
29-Aug-94	6.89	1	0.136	0.017	0.08	0.01	0.06	0.10	0.38	<0.002	0.075		<0.03
06-Sep-94	7.20	1	0.274	0.025	<0.01	<0.01	0.05	0.05	0.37	<0.002	0.140	<0.0001	<0.03
12-Sep-94	6.68	<1	0.395	0.011	<0.01	<0.01	0.05	0.14	0.30	<0.002	0.209		<0.03
19-Sep-94	6.20	<1	0.065	0.010	0.01	0.02	0.06	0.05	0.34	<0.002	0.166		<0.03
26-Sep-94	7.17	<1	0.046	0.007	<0.01	0.07	0.03	0.23	0.35	<0.002	0.127		<0.03
03-Oct-94	No Discharge												
11-Oct-94	6.71	<1	0.530	0.018	<0.01	<0.01	0.04	0.16	0.28	<0.002	0.253		<0.03
17-Oct-94	6.40	2	0.285	0.016	<0.01	<0.01	0.04	0.13	0.29	<0.002	0.295		<0.03
24-Oct-94	6.96	2	0.310	0.014	<0.01	0.01	0.04	0.14	0.29	<0.002	0.236		<0.03
01-Nov-94	7.03	2	0.300	0.019	<0.01	<0.01	<0.02	0.34	0.64	<0.002	0.240		<0.03
07-Nov-94	6.60	1	0.125	0.028	<0.01	<0.01	0.03	0.12	0.46	<0.002	0.201	<0.0001	<0.03
14-Nov-94	7.00	2	0.150	0.070	<0.01	<0.01	0.05	0.26	0.49	<0.002	0.175		<0.03
21-Nov-94	6.82	1	0.380	0.256	<0.01	0.03	0.08	0.28	0.40	<0.002	0.145		<0.03
28-Nov-94	6.18	1	0.635	0.445	<0.01	<0.01	0.16	0.35	0.29	<0.002	0.165		<0.03
05-Dec-94	6.79	<1	0.695	0.375	<0.01	0.01	0.14	0.29	0.24	<0.002	0.131	<0.0001	<0.03
12-Dec-94	6.97	2	0.465	0.400	0.23	<0.01	0.12	0.28	0.55	<0.002	0.141		<0.03
19-Dec-94	Plant Shut Down												
27-Dec-94	No Discharge												

Parameters reported in mg/L, total metals

Appendix 3

Certificate of Approval for Campbell Mine



Ministry of the Environment
Ministère de l'Environnement
Ontario

APPROVALS BRANCH
3rd Floor
Tel. (416) 440-7019
Fax (416) 440-6973

250 Davisville Avenue
Toronto, Ontario
M4S 1H2

250, avenue Davisville
Toronto (Ontario)
M4S 1H2

July 10, 1992

Mr. Tim Mann,
Mine Manager, Campbell Mine
Placer Dome Inc.
Box 10, Mine Road
Balmertown, Ontario
P0V 1C0

Dear Mr. Mann:

Re: **Placer Dome Inc., Campbell Mine**
Wastewater Treatment Plant
Certificate of Approval (Sewage)
No. 4-058-86-928

Please find enclosed the Ministry's Certificate of Approval No. 4-058-86-928. This certificate consolidates the approvals issued under Certificate No. 4-058-86-917 dated June 5, 1991 and includes the approval of new facilities that were outlined in your application dated April 3, 1992. Therefore with the issuance of Certificate No. 4-058-86-928, Certificate No. 4-058-86-917 is considered revoked as a separate Certificate of Approval.

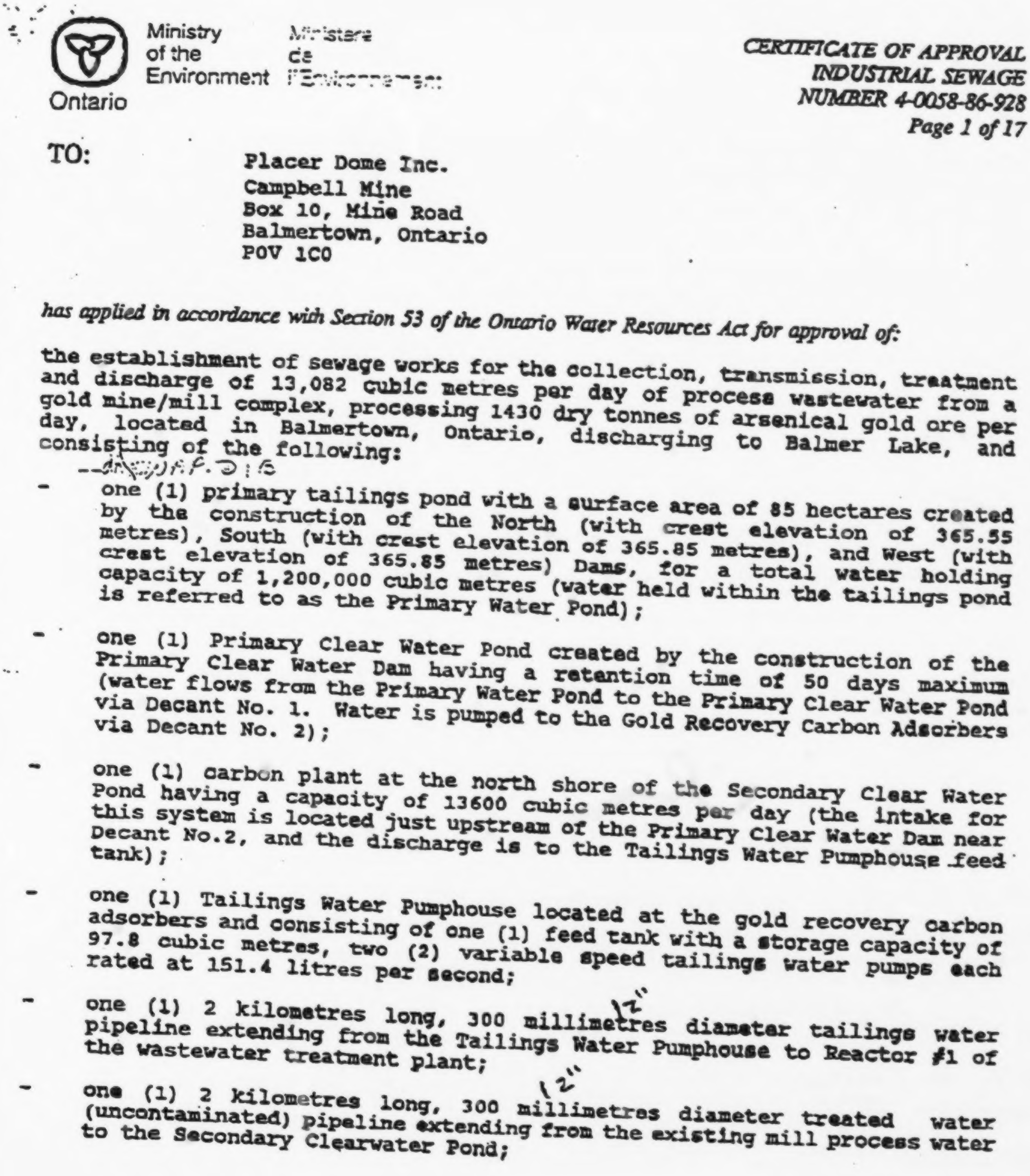
As you are aware, this Ministry is proposing comprehensive regulations which will require various types of discharges to be monitored and meet specified criteria. When the regulations are in place, you will have to comply with them. If it is necessary to modify the sewage works to comply with them, you will have to apply for the appropriate approvals at that time.

Should you have any inquires regarding the above, please do not hesitate to contact Mr. R. Chin of this office at (416) 440-3736.

Yours truly,

T.D. Armstrong, P.Eng.
Director,
Section 53, O.W.R. Act,
Ministry of the Environment.

RC/gw
Encl.
c.c.:-Mr. W. Scott, MOE NW, Reg. Dir.
-Mr. John Barr, Kenora District Office, MOE



Ministry of the Environment
Ministère de l'Environnement
Ontario

CERTIFICATE OF APPROVAL
INDUSTRIAL SEWAGE
NUMBER 4-0058-86-928
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TO:

Placer Dome Inc.
Campbell Mine
Box 10, Mine Road
Balmertown, Ontario
P0V 1C0

has applied in accordance with Section 53 of the Ontario Water Resources Act for approval of:

the establishment of sewage works for the collection, transmission, treatment and discharge of 13,082 cubic metres per day of process wastewater from a gold mine/mill complex, processing 1430 dry tonnes of arsenical gold ore per day, located in Balmertown, Ontario, discharging to Balmer Lake, and consisting of the following:

- one (1) primary tailings pond with a surface area of 85 hectares created by the construction of the North (with crest elevation of 365.55 metres), South (with crest elevation of 365.85 metres), and West (with crest elevation of 365.85 metres) Dams, for a total water holding capacity of 1,200,000 cubic metres (water held within the tailings pond is referred to as the Primary Water Pond);

- one (1) Primary Clear Water Pond created by the construction of the Primary Clear Water Dam having a retention time of 50 days maximum (water flows from the Primary Water Pond to the Primary Clear Water Pond via Decant No. 1. Water is pumped to the Gold Recovery Carbon Adsorbers via Decant No. 2);

- one (1) carbon plant at the north shore of the Secondary Clear Water Pond having a capacity of 13600 cubic metres per day (the intake for this system is located just upstream of the Primary Clear Water Dam near Decant No.2, and the discharge is to the Tailings Water Pumphouse feed tank);

- one (1) Tailings Water Pumphouse located at the gold recovery carbon adsorbers and consisting of one (1) feed tank with a storage capacity of 97.8 cubic metres, two (2) variable speed tailings water pumps each rated at 151.4 litres per second;

- one (1) 2 kilometres long, 300 12" millimetres diameter tailings water pipeline extending from the Tailings Water Pumphouse to Reactor #1 of the wastewater treatment plant;

- one (1) 2 kilometres long, 300 12" millimetres diameter treated water (uncontaminated) pipeline extending from the existing mill process water to the Secondary Clearwater Pond;

9

- one (1) 3-stage INCO SO_2/Air Wastewater Treatment Plant with a maximum design flow capacity of 151.4 litres per second consisting of two (2) cyanide destruction reactor tanks each 7.3 metres in diameter and 7.3 metres high equipped with agitator mixers, one (1) 6.1 metres diameter and 6.3 metres high clarifier feed tank; two (2) clarifier feed pumps each rated at 151.4 litres per second; one (1) 33 metres diameter 4 metres high hopper clarifier, one (1) 2.4 metres diameter and 6.1 metres high clarifier overflow pump tank, two (2) clarifier overflow pumps each rated at 151.4 litres per second discharging to the existing mill water tank, the Primary Clear Water Pond and the Secondary Clear Water Pond, including associated chemical reagent mixing and storage facilities;

- one (1) Secondary Clearwater Pond formed by the Secondary Clear Water Dam having a retention time of 16 days and a surface area of 4 hectares (water from the Secondary Clear Water Pond is released into Balmer Lake via Decant No. 3);

- A lined containment facility is located at site D as outlined in Map No. 1.2, dated January 1991, consisting of one (1) pond with a storage capacity of between 3 and 7 years, lined with a composite liner system consisting of a 60 millimetre HDPE liner along the base of the ponds and an 80 millimetre HDPE liner along the sidehill slopes and each with internal and external sideslopes of the embankments are both 2.5:1 (H:V) with the crest of the embankments measuring 5 metres in width, including underdrains laid in a herringbone formation beneath the base of the liner;

- a 1650 metres long drainage ditch located along the west side of the Primary Tailings Pond, Primary Clear Water Pond and the Secondary Clear Water Pond, discharging to Balmer Lake;

- all piping, appurtenances, and structural works to provide treatment and controlled discharge of the treated effluent from the Secondary Clear Water Pond to Balmer Lake.

all in accordance with the information listed in the attached Schedule "A".

This Certificate of Approval supersedes Certificate of Approval No. 4-058-86-917 dated June 5, 1991.

You are hereby notified that this approval is issued to you subject to the following terms and conditions outlined below:

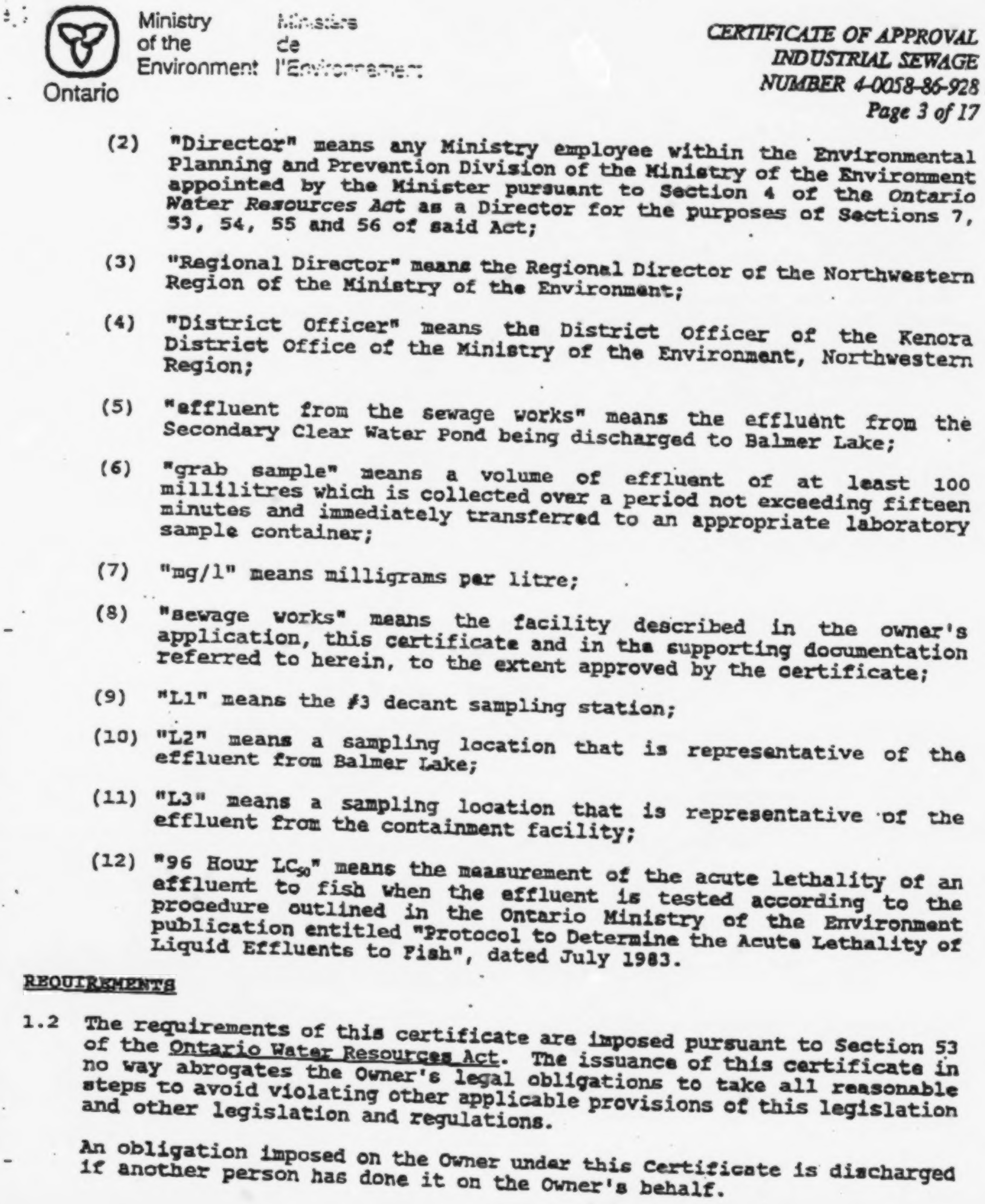
TERMS AND CONDITIONS

SECTION 1 GENERAL

DEFINITIONS

1.1 For the purpose of this Certificate of Approval:

(1) "Owner" means Placer Dome Inc., Campbell Mine;



(2) "Director" means any Ministry employee within the Environmental Planning and Prevention Division of the Ministry of the Environment appointed by the Minister pursuant to Section 4 of the *Ontario Water Resources Act* as a Director for the purposes of Sections 7, 53, 54, 55 and 56 of said Act;

(3) "Regional Director" means the Regional Director of the Northwestern Region of the Ministry of the Environment;

(4) "District Officer" means the District Officer of the Kenora District Office of the Ministry of the Environment, Northwestern Region;

(5) "effluent from the sewage works" means the effluent from the Secondary Clear Water Pond being discharged to Balmer Lake;

(6) "grab sample" means a volume of effluent of at least 100 millilitres which is collected over a period not exceeding fifteen minutes and immediately transferred to an appropriate laboratory sample container;

(7) "mg/l" means milligrams per litre;

(8) "sewage works" means the facility described in the owner's application, this certificate and in the supporting documentation referred to herein, to the extent approved by the certificate;

(9) "L1" means the #3 decant sampling station;

(10) "L2" means a sampling location that is representative of the effluent from Balmer Lake;

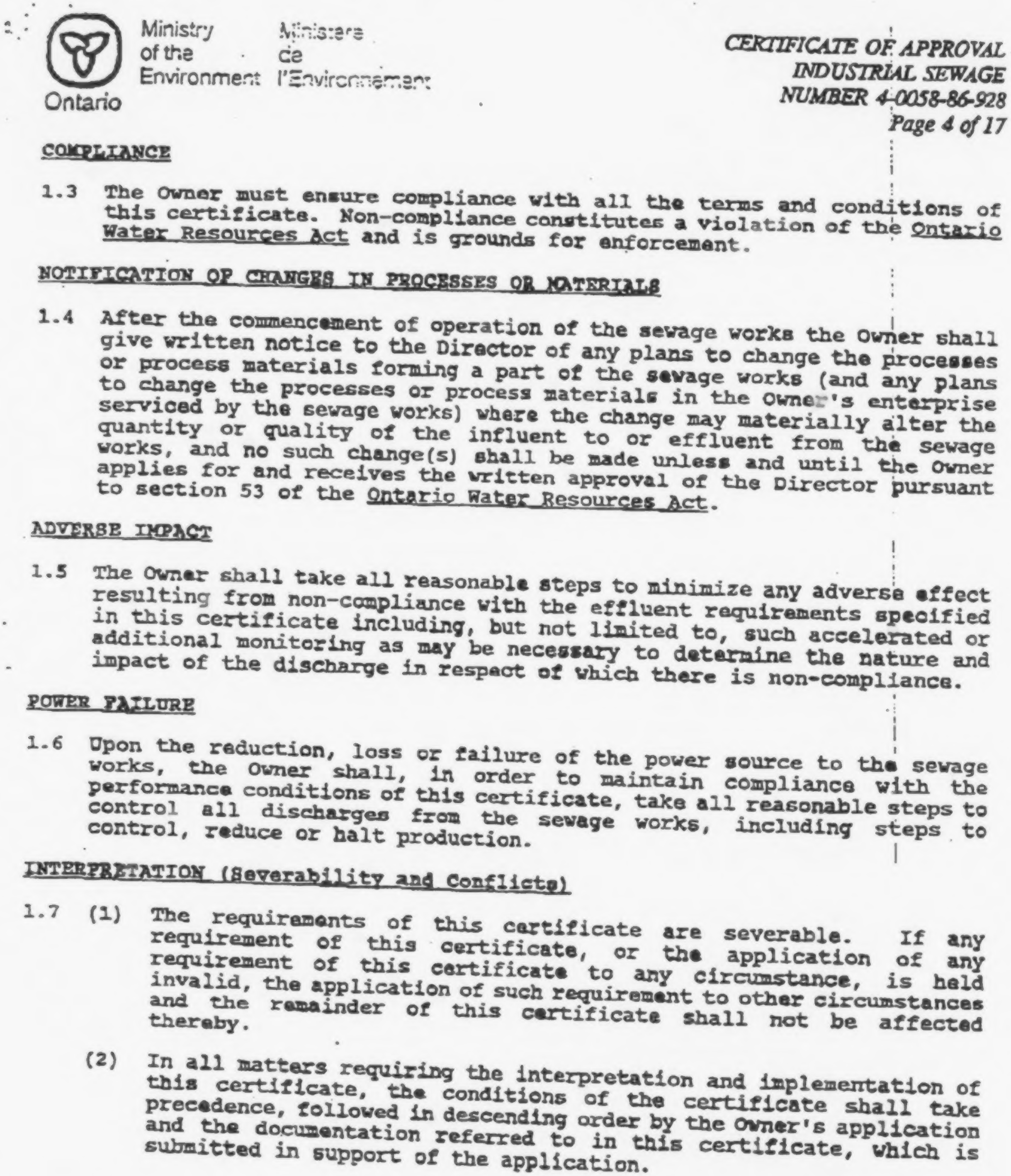
(11) "L3" means a sampling location that is representative of the effluent from the containment facility;

(12) "96 Hour LC_{50}" means the measurement of the acute lethality of an effluent to fish when the effluent is tested according to the procedure outlined in the Ontario Ministry of the Environment publication entitled "Protocol to Determine the Acute Lethality of Liquid Effluents to Fish", dated July 1983.

REQUIREMENTS

1.2 The requirements of this certificate are imposed pursuant to Section 53 of the Ontario Water Resources Act. The issuance of this certificate in no way abrogates the Owner's legal obligations to take all reasonable steps to avoid violating other applicable provisions of this legislation and other legislation and regulations.

An obligation imposed on the Owner under this Certificate is discharged if another person has done it on the Owner's behalf.



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COMPLIANCE

1.3 The Owner must ensure compliance with all the terms and conditions of this certificate. Non-compliance constitutes a violation of the Ontario Water Resources Act and is grounds for enforcement.

NOTIFICATION OF CHANGES IN PROCESSES OR MATERIALS

1.4 After the commencement of operation of the sewage works the Owner shall give written notice to the Director of any plans to change the processes or process materials forming a part of the sewage works (and any plans to change the processes or process materials in the Owner's enterprise serviced by the sewage works) where the change may materially alter the quantity or quality of the influent to or effluent from the sewage works, and no such change(s) shall be made unless and until the Owner applies for and receives the written approval of the Director pursuant to section 53 of the Ontario Water Resources Act.

ADVERSE IMPACT

1.5 The Owner shall take all reasonable steps to minimize any adverse effect resulting from non-compliance with the effluent requirements specified in this certificate including, but not limited to, such accelerated or additional monitoring as may be necessary to determine the nature and impact of the discharge in respect of which there is non-compliance.

POWER FAILURE

1.6 Upon the reduction, loss or failure of the power source to the sewage works, the Owner shall, in order to maintain compliance with the performance conditions of this certificate, take all reasonable steps to control all discharges from the sewage works, including steps to control, reduce or halt production.

INTERPRETATION (Severability and Conflicts)

1.7 (1) The requirements of this certificate are severable. If any requirement of this certificate, or the application of any requirement of this certificate to any circumstance, is held invalid, the application of such requirement to other circumstances and the remainder of this certificate shall not be affected thereby.

(2) In all matters requiring the interpretation and implementation of this certificate, the conditions of the certificate shall take precedence, followed in descending order by the Owner's application and the documentation referred to in this certificate, which is submitted in support of the application.

AS-CONSTRUCTED DRAWINGS

1.8 (1) The Owner shall prepare within six (6) months of the start up of the pressure oxidation system, a complete set of drawings showing the sewage works as-constructed and shall, within six (6) months after changes in or additions to the sewage works, amend the drawings to reflect said changes or additions.

(2) The Owner shall maintain the as-constructed drawings, as amended, at the location of the sewage works for so long as it is in operation, and shall make them available for inspection by Ministry employees upon request.

CHANGE OF OWNER

1.9 (1) The Owner shall notify the District Officer in writing of any of the following changes within thirty (30) days of the change occurring:

(a) change of Owner or operator or both;

(b) change of address or address of new Owner;

(c) change of partners where the Owner or operator is or at any time becomes a partnership, and a copy of the most recent declaration filed under the Partnerships Registration Act shall be included in the notification to the District Officer;

(d) change of name of the corporation where the Owner or operator is or at any time becomes a corporation, and a copy of the most current "Initial Notice or Notice of Change" (Form 1, 2 or 3 of O.Reg. 189, R.R.O. 1980, as amended from time to time), filed under the Corporations Information Act shall be included in the notification to the District Officer;

(2) In the event of any change in ownership of the sewage works, the Owner shall notify in writing the succeeding Owner of the existence of this certificate, and a copy of such notice shall be forwarded to the District Officer.

SECTION 2 OPERATION AND MAINTENANCE

OPERATION AND MAINTENANCE

2.1 (1) The Owner shall ensure that at all times, the sewage works and related equipment and appurtenances which are installed or used to achieve compliance with this certificate are properly operated and maintained.

(2) In furtherance of, but without limiting the generality of, the obligation imposed by subsection (1) the Owner shall ensure that:

(a) funding, staffing, training of staff, laboratory and process controls, quality assurance and quality control procedures of or in relation to the sewage works are adequate to achieve compliance with this certificate; and,

(b) equipment and material are kept on hand and in good repair for immediate use in the event of:

(i) upset;

(ii) bypass;

(iii) abnormal loss of any product, by-product, intermediate product, oil, solvent, waste material or any other polluting substance into the environment or interior of any building; or,

(iv) spill within the meaning of Part X of the Environmental Protection Act,

and staff are trained in the use of said equipment and material and in the methods and procedures to be employed upon the occurrence of such an event.

(3) No discharge from the Tertiary Clear Water Pond (Balmer Lake) will be permitted from May 1st to July 1st of any year without prior written approval from the District Officer or his or her representative.

OPERATIONS MANUAL

2.2 (1) In furtherance of, but without limiting the generality of the obligation imposed by Condition 2.1(1), the Owner shall prepare and implement the operations manual for the sewage works within 12 months of the start up of the pressure oxidation system.

(2) The Owner shall ensure that the manual includes as a minimum:

(a) operating procedures for routine operation of the sewage works;

(b) inspection programs, including frequency of inspection, for the sewage works and the methods or tests employed to detect when maintenance is necessary;

(c) repair and maintenance programs, including the frequency of repair and maintenance for the sewage works;

(d) any other plans and procedures which are necessary because of the special nature of the facilities served by the sewage works, the materials used in those facilities or in the sewage works, the sewage works itself or the location thereof;

(e) complaint procedures for receiving and responding to public complaints, including a reporting system which records what steps the Owner took to determine the cause of the complaint and what corrective measures were taken to alleviate the cause and prevent its recurrence;

(f) a list of the personnel positions responsible for the operation of the sewage works, including supervisory and laboratory personnel and personnel responsible for recording and reporting pursuant to the requirements of this certificate, along with the training and experience required for the positions and a description of the responsibilities;

(g) contingency plans and procedures setting out how material equipment breakdowns in the sewage works, upsets, abnormal losses of any product, by-product, intermediate product, oil, solvent, waste material or any other polluting substance into the environment or interior of any building and spills within the meaning of Part X of the Environmental Protection Act will be dealt with to prevent or minimize material gas or odour emissions or sewage or other material contaminant discharges, into the natural environment, including:

 (i) a list of equipment, material and personnel that will be available at the sewage works or will be called to the sewage works to deal with the situations noted above;

 (ii) a description of methods and procedures to be employed in dealing with the situations noted above including restrictions on production to reduce sewage flows; and,

 (iii) the procedures to be used to notify the Ministry and, where relevant, municipal authorities forthwith, of the situation being encountered as well as the measures being taken and proposed to deal with it;

(3) The Owner shall maintain the operations manual, as revised from time to time, at the location of the sewage works for so long as it is in operation, and shall make it available for inspection and copying by Ministry employees upon request.

(4) The Owner shall keep the operations manual up to date through revisions undertaken from time to time, so as to reflect any changes in described operation and maintenance procedures for the sewage works or any newly introduced operation and maintenance procedures made necessary by good engineering practice, this certificate or the requirements of the Ministry.

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Ministère de l'Environnement
Ontario

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SECTION 3 PERFORMANCE

EFFLUENT REQUIREMENTS

3.1 Effective immediately, the Owner shall continue to operate the sewage works in compliance with the requirements outlined in Condition 3.1(1) of Certificate of Approval no. 4-058-86-917 dated June 5, 1991 until nine (9) months after commencement of operation of the Tailings Water Pumphouse and forcemain, the INCO SO_2/Air Wastewater Treatment System and the 1650 metres long drainage ditch, as described above, or until June 1, 1993, whichever occurs first. Following this period, the sewage works shall be designed, constructed and operated in accordance with the following:

(1) (a) The Owner shall design, construct and operate the sewage works such that the 96 hour LC_{50} concentration at L2 is 100 % effluent or greater.

If good After one year
at L2 LC50 drop LC50

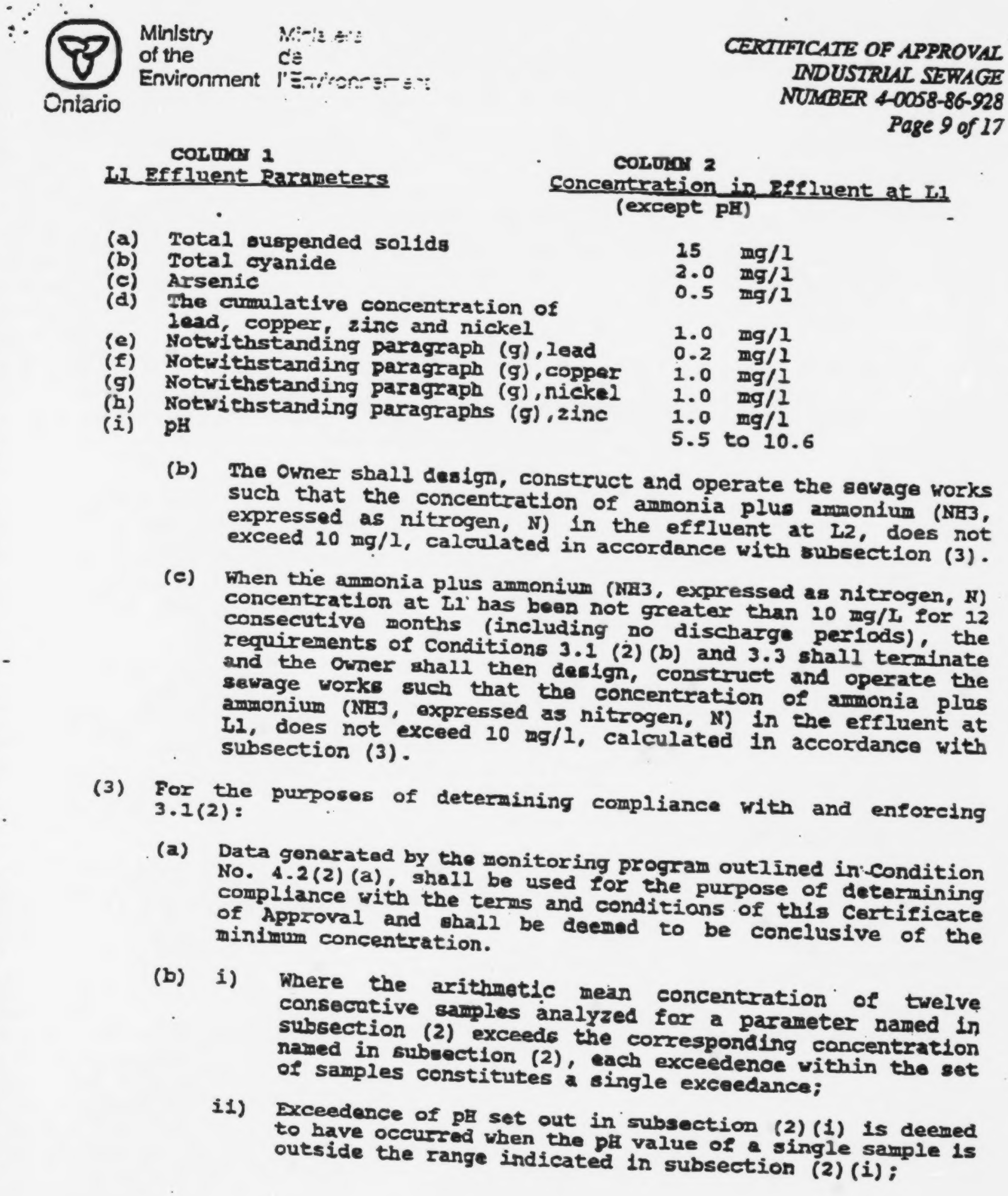
(b) When the 96 hour LC_{50} concentration at L1 has been 100% effluent or greater for 12 consecutive months (including no discharge periods), the requirements of Conditions 3.1(1)(a) and 3.2 shall terminate and the Owner shall then design, construct and operate the sewage works such that the 96 hour LC_{50} concentration at L1 is 100 % effluent or greater.

↑

(c) For the purpose of determining compliance to 3.1(1)(a) and (b), the following will apply:

Should the result of an individual sample contravene the value outlined in 3.1(1)(a) or (b), then an additional sample shall be obtained within 72 hours of receipt of the initial 96 hour LC_{50} result and analyzed for 96 hour LC_{50}. If the value in 3.1(1)(a) or (b) is again contravened or if no second sample is obtained, then the Condition shall be deemed to be singly contravened.

(2) (a) The Owner shall design, construct and operate the sewage works such that the concentration of the parameters listed in Column 1 below in the effluent from the works, do not exceed the corresponding values listed in Column 2 below, calculated in accordance with subsection (3).



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	COLUMN 1 L1 Effluent Parameters	COLUMN 2 Concentration in Effluent at L1 (except pH)
(a)	Total suspended solids	15 mg/l
(b)	Total cyanide	2.0 mg/l
(c)	Arsenic	0.5 mg/l
(d)	The cumulative concentration of lead, copper, zinc and nickel	1.0 mg/l
(e)	Notwithstanding paragraph (g),lead	0.2 mg/l
(f)	Notwithstanding paragraph (g),copper	1.0 mg/l
(g)	Notwithstanding paragraph (g),nickel	1.0 mg/l
(h)	Notwithstanding paragraphs (g),zinc	1.0 mg/l
(i)	pH	5.5 to 10.6

(b) The Owner shall design, construct and operate the sewage works such that the concentration of ammonia plus ammonium (NH3, expressed as nitrogen, N) in the effluent at L2, does not exceed 10 mg/l, calculated in accordance with subsection (3).

(c) When the ammonia plus ammonium (NH3, expressed as nitrogen, N) concentration at L1 has been not greater than 10 mg/L for 12 consecutive months (including no discharge periods), the requirements of Conditions 3.1 (2)(b) and 3.3 shall terminate and the Owner shall then design, construct and operate the sewage works such that the concentration of ammonia plus ammonium (NH3, expressed as nitrogen, N) in the effluent at L1, does not exceed 10 mg/l, calculated in accordance with subsection (3).

(3) For the purposes of determining compliance with and enforcing 3.1(2):

(a) Data generated by the monitoring program outlined in Condition No. 4.2(2)(a), shall be used for the purpose of determining compliance with the terms and conditions of this Certificate of Approval and shall be deemed to be conclusive of the minimum concentration.

(b) i) Where the arithmetic mean concentration of twelve consecutive samples analyzed for a parameter named in subsection (2) exceeds the corresponding concentration named in subsection (2), each exceedence within the set of samples constitutes a single exceedance;

ii) Exceedence of pH set out in subsection (2)(i) is deemed to have occurred when the pH value of a single sample is outside the range indicated in subsection (2)(i);

EFFLUENT OBJECTIVES

3.2 Effective nine (9) months after commencement of operation of the Tailings Water Pumphouse and forcemain, the INCO SO_2/Air Wastewater Treatment System and the 1650 metres long drainage ditch, as described above, or on June 1, 1993, whichever occurs first:

(1) The Owner shall use best efforts to design, construct and operate the works with the objective that the 96 hour LC_{50} concentration at L1 is 100 % effluent or greater.

(2) This condition shall terminate once the 96 hour LC_{50} concentration at L1 has been 100% effluent or greater for 12 consecutive months (including no discharge periods).

(3) The Owner shall include in all routine and performance reports submitted in accordance with Condition 5.1 a summary of the efforts made and results achieved under this Condition.

3.3 Effective nine (9) months after commencement of operation of the Tailings Water Pumphouse and forcemain, the INCO SO_2/Air Wastewater Treatment System and the 1650 metres long drainage ditch, as described above, or on June 1, 1993, whichever occurs first:

(1) The Owner shall use best efforts to design, construct and operate the works with the objective that the concentration of ammonia plus ammonium (NH3, expressed as nitrogen, N) at L1 is not greater than 10 mg/l.

(2) This condition shall terminate once the concentration of ammonia plus ammonium (NH3, expressed as nitrogen, N) at L1 is no longer greater than 10 mg/l.

(3) The Owner shall include in all routine and performance reports submitted in accordance with Condition 5.1 a summary of the efforts made and results achieved under this Condition.

SECTION 4 MONITORING AND RECORDING

SAMPLES AND MEASUREMENTS

4.1 The Owner shall ensure that samples and measurements taken for the purposes of this certificate are taken at a time and in a location characteristic of the quality and quantity of the effluent stream or receiving water body, as the case may be, over the time period being monitored.

EFFLUENT QUALITY MONITORING

4.2 Effective immediately, the Owner shall establish and carry out the following effluent monitoring program and shall continue to monitor the operations of the sewage works in compliance with the requirements outlined in Condition 4.2 of Certificate of Approval no. 4-058-86-917 dated June 5, 1991 until nine (9) months after commencement of operation of the Tailings Water Pumphouse and forcemain, the INCO SO_2/Air Wastewater Treatment System and the 1650 metres long drainage ditch, as described above, or until June 1, 1993, whichever occurs first. Following this period, the monitoring in accordance with Condition 4.2 of Certificate of Approval 4-058-86-917 dated June 5, 1991 may be terminated upon the written concurrence of the District Officer.

(1) The sampling locations as set out in subsection (2) and in section 4.4(1) shall be established to the satisfaction of the District Officer. These sampling locations may be changed or abandoned and new locations may be added if, in the reasonable opinion of the District Officer, it is necessary to do so to ensure representative samples are being collected.

(2) Grab samples shall be collected and analyzed for the following parameters at the frequency shown:

Parameter Measured	Location/Frequency		
	L1	L2	L3
(a) Total suspended solids	3/w	----	m
(b) Ammonia plus ammonium (NH3, expressed as N)	3/w	3/w	----
(c) Cyanide (Total)	3/w	----	m
(d) Cyanide (Weak Acid Dissociable)	3/w	----	m
(e) Thiocyanates	3/w	----	m
(f) Lead	3/w	----	m
(g) Copper	3/w	----	m
(h) Nickel	3/w	----	m
(i) Zinc	3/w	----	m
(j) Arsenic	3/w	----	m
(k) Iron	3/w	----	m

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Parameter Measured		Location/Frequency		
		L1	L2	L3
(l)	Mercury	m	----	m
(m)	Hardness	3/w	----	----
(n)	Conductivity	3/w	----	----
(o)	Alkalinity	3/w	----	----
(p)	Sulphate	3/w	----	m
(q)	pH	3/w	----	m
(r)	96 hour LC50	d- (m)	d- (m)	----

[(s) ~~flow measurement to be taken at time of sampling~~ MISA (continuou

(t) temperature of effluent to be taken at the time of sampling

Where:
d - during discharge
3/w - three times per week
m - monthly

(3) The time interval between consecutive tri-weekly and monthly samples shall be, at least 2 and 30 days respectively.

(4) After the Owner obtains a minimum of 24 months of sampling and analytical results, the sampling and monitoring frequency indicated in subsection (2) may be changed, to such frequency as the District Officer may specify in writing from time to time.

(5) The methods and protocols for sampling and analysis shall conform, in order of precedence, to the methods and protocols specified in the following:

- (a) the Ministry's publication "Protocol for the Sampling and Analysis of Industrial/Municipal Wastewater" (October 1991), ISBN 0-7729-8970-2, as amended from time to time by more recently published editions;
- (b) the publication "Standard Methods for the Examination of Water and Wastewater" (17th edition) as amended from time to time by more recently published editions; and,
- (c) the Environment Canada publications "Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout" (July 1990) and "Reference Method for Determining Acute Lethality of Effluents to Daphnia magna" (July 1990);

(d) in respect of any parameters not mentioned in (a) - (c), the written approval of the District Officer, which approval shall be obtained prior to sampling.

(6) Once the 96 hour LC_{50} concentration at L1 has been 100% effluent or greater for 12 consecutive months (including no discharge periods), the 96 hour LC_{50} monitoring at L2 may be terminated.

EFFLUENT FLOW MEASUREMENT

4.3 (1) (a) The Owner shall maintain flow measuring devices in effluent streams at sampling stations L1 and L3 with an accuracy to within plus or minus 15 per cent of the actual discharge flowrate for the entire design range of the flow measuring devices, which must be operable under winter conditions.

(b) The Owner shall measure, record and calculate the flowrate for the effluent streams referred to in subsection (1)(a) on each day sampling is undertaken pursuant to Condition 4.2(2).

(2) The Owner shall calibrate the flow measuring devices used in connection with this Condition at least once per year to ensure that the accuracy meets the requirements specified herein.

(3) The flow monitoring locations as set out in subsection (1) shall be established to the satisfaction of the District Officer prior to the start up of the pressure oxidation system. The flow monitoring location may be changed or abandoned and new locations may be added following commencement of operation if, in the reasonable opinion of the District Officer, it is necessary to do so to ensure representative flows are being measured.

RECEIVING WATER MONITORING

4.4 The Owner shall establish and carry out the following receiving water monitoring program:

(1) The receiving water assessment of the Chukuni River shall consist of:

(a) Grab samples to be taken on a monthly basis from the Chukuni River upstream and downstream of its junction with Balmer Creek to permit the analysis of the parameters listed in Condition 4.2(2), except toxicity.

(b) For all parameters for which the Ministry has an established Provincial Water Quality Objective in Table 1 of the Ministry publication,"Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment" (November 1978, revised May 1984), as amended from time to time, the analytical method detection limit for each such parameter shall be less than the aforesaid Provincial Water Quality Objective for the parameter sampled.

GROUNDWATER AND INTERSTITIAL WATER MONITORING

4.5 Effective three (3) months following start-up of the pressure oxidation system, the Owner shall undertake a groundwater and interstitial water monitoring program which has been established to the written satisfaction of the District Officer. The groundwater monitoring program shall include but shall not be limited to the parameters listed in Condition 4.2(2)(a).

RECORD RETENTION

4.6 The Owner shall retain for a period of five (5) years from the date of their creation, all records and information related to or resulting from the monitoring activities required by this certificate, including, without restricting the generality of the foregoing:

(a) all recordings from monitoring devices, including all original strip chart recordings from continuous monitoring devices;

(b) all laboratory analytical results relating to samples taken pursuant to the monitoring program(s) set out in Condition(s) 4.2(2), 4.3(1) and 4.4(1);

(c) all calibration and maintenance records including associated log books associated with Condition(s) 4.3(2) and 5.1 (b);

(d) all records of plant upsets and sewage bypasses associated with Condition(s) 5.1(c);

SECTION 5 REPORTING

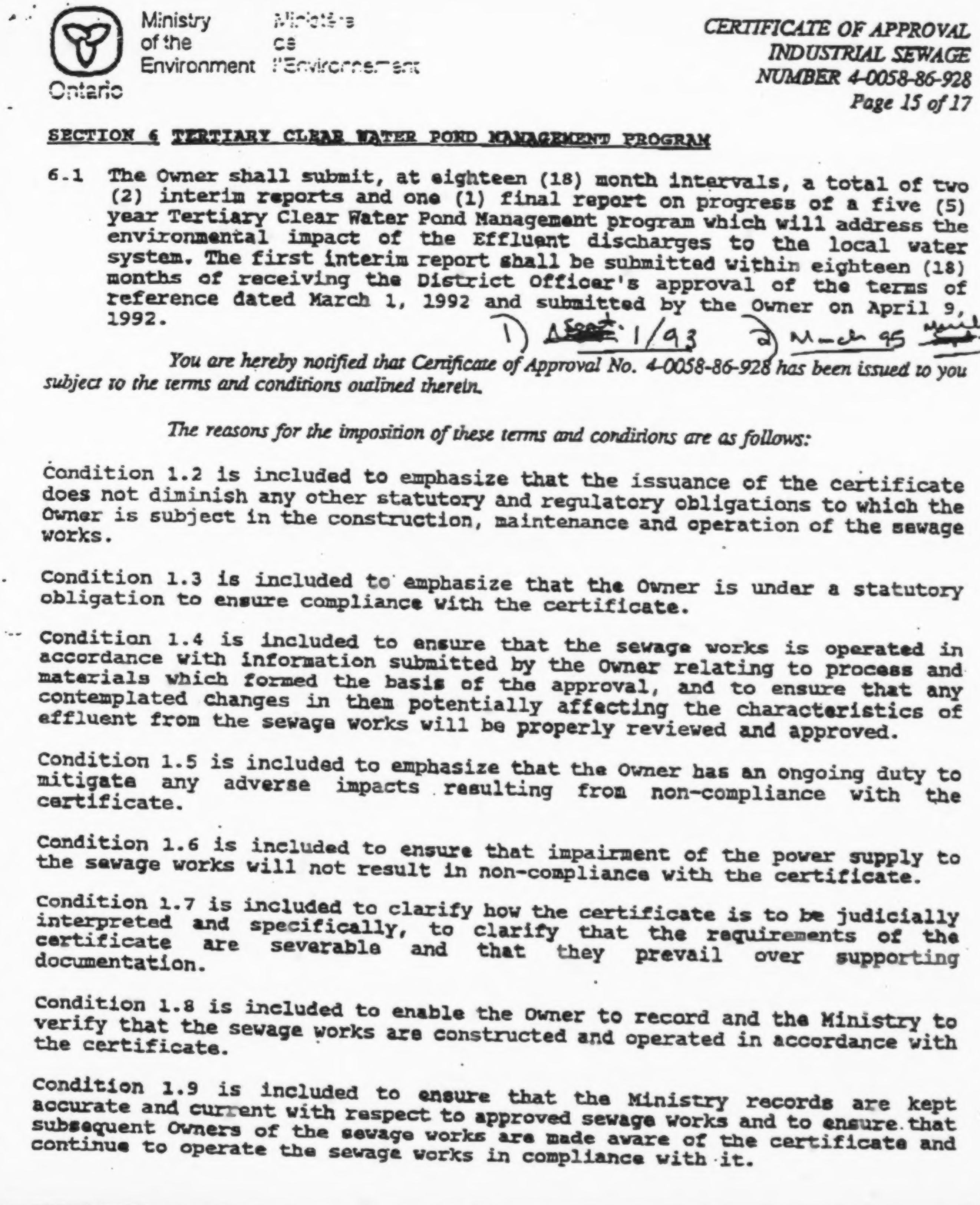
ROUTINE REPORTING

5.1 The Owner shall prepare and submit a monitoring and compliance report to the District Officer on a monthly basis within forty (40) days following the period being reported upon. The reports shall contain, but shall not be limited to, the following information in a format acceptable to the District Officer:

(a) a summary and interpretation of all monitoring data and analytical data collected relative to the sewage works during the reporting period.

(b) a summary and interpretation of all calibration and maintenance procedures carried out during the reporting period;

(c) a tabulation and description of any bypass or upset conditions which occurred during the period being reported upon;



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SECTION 6 TERTIARY CLEAR WATER POND MANAGEMENT PROGRAM

6.1 The Owner shall submit, at eighteen (18) month intervals, a total of two (2) interim reports and one (1) final report on progress of a five (5) year Tertiary Clear Water Pond Management program which will address the environmental impact of the Effluent discharges to the local water system. The first interim report shall be submitted within eighteen (18) months of receiving the District Officer's approval of the terms of reference dated March 1, 1992 and submitted by the Owner on April 9, 1992.

1) [illegible] 1/93 2) March 95 [illegible]

You are hereby notified that Certificate of Approval No. 4-0058-86-928 has been issued to you subject to the terms and conditions outlined therein.

The reasons for the imposition of these terms and conditions are as follows:

Condition 1.2 is included to emphasize that the issuance of the certificate does not diminish any other statutory and regulatory obligations to which the Owner is subject in the construction, maintenance and operation of the sewage works.

Condition 1.3 is included to emphasize that the Owner is under a statutory obligation to ensure compliance with the certificate.

Condition 1.4 is included to ensure that the sewage works is operated in accordance with information submitted by the Owner relating to process and materials which formed the basis of the approval, and to ensure that any contemplated changes in them potentially affecting the characteristics of effluent from the sewage works will be properly reviewed and approved.

Condition 1.5 is included to emphasize that the Owner has an ongoing duty to mitigate any adverse impacts resulting from non-compliance with the certificate.

Condition 1.6 is included to ensure that impairment of the power supply to the sewage works will not result in non-compliance with the certificate.

Condition 1.7 is included to clarify how the certificate is to be judicially interpreted and specifically, to clarify that the requirements of the certificate are severable and that they prevail over supporting documentation.

Condition 1.8 is included to enable the Owner to record and the Ministry to verify that the sewage works are constructed and operated in accordance with the certificate.

Condition 1.9 is included to ensure that the Ministry records are kept accurate and current with respect to approved sewage works and to ensure that subsequent Owners of the sewage works are made aware of the certificate and continue to operate the sewage works in compliance with it.

Condition 2.1 is included to ensure that the sewage works will be operated, maintained, funded, staffed and equipped in a manner enabling compliance with the terms and conditions of this certificate, such that the environment is protected and deterioration, loss, injury or damage to any person or property is prevented.

Condition 2.2 is included to ensure that a comprehensive operations manual governing all significant areas of operation, maintenance and repair is prepared, implemented and kept up-to-date by the Owner and made available to the Ministry. Such a manual is an integral part of the operation of the sewage works. Its compilation and use should assist the Owner in staff training, in proper plant operation and in identifying and planning for contingencies during possible abnormal conditions. The manual will also act as a benchmark for Ministry staff when reviewing the Owner's operation of the work. Because of the time required to compile this comprehensive document, the Owner has been permitted to prepare and revise a draft manual to be fully implemented within 12 months of the commencement of operations.

Conditions 3.1 is imposed to ensure that the effluent discharged from the sewage works meets the Ministry's effluent quality requirements as specified on a continual basis thus minimizing environmental impact to the receiver.

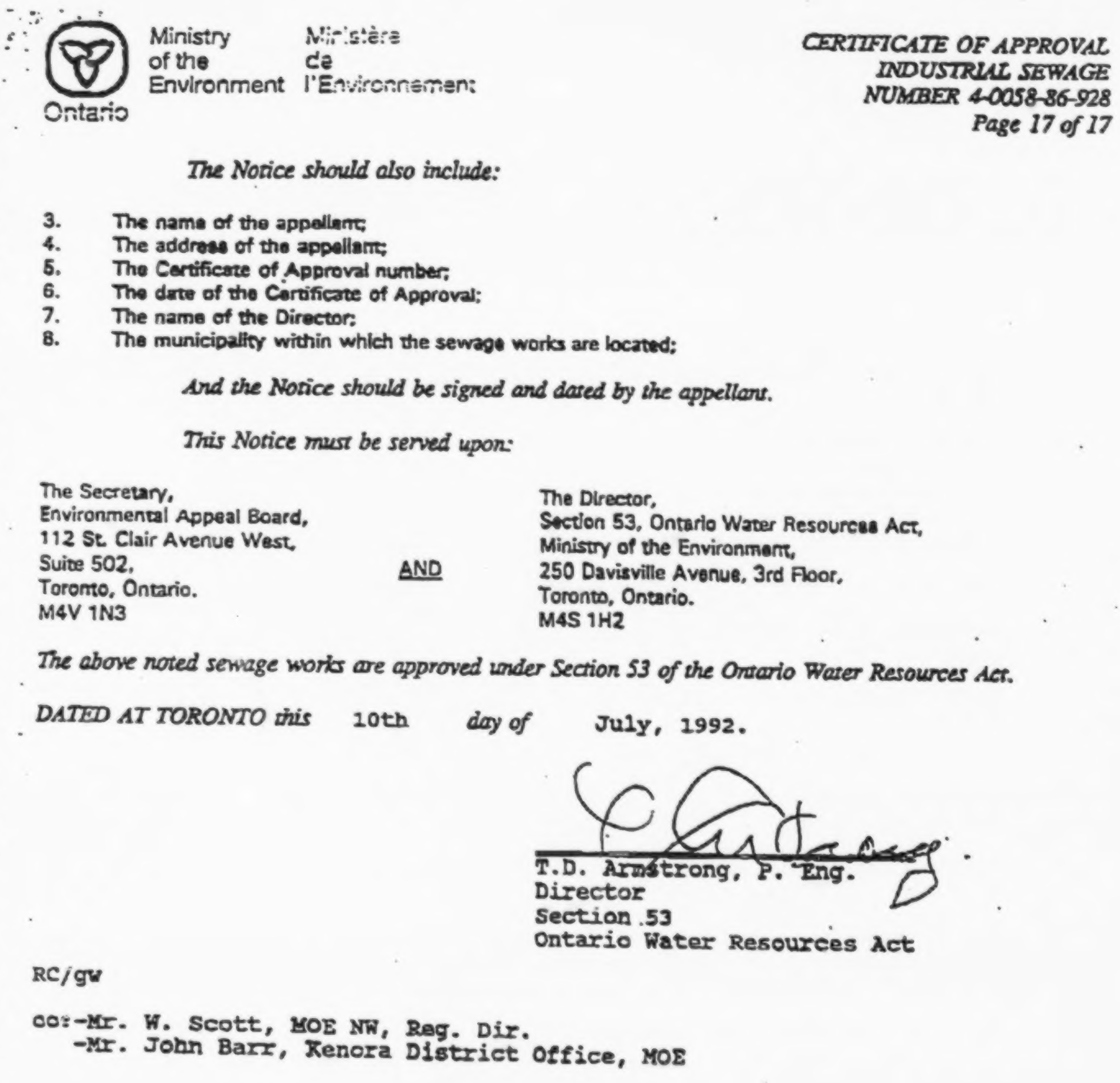
Conditions 3.2 and 3.3 are imposed to establish non-enforceable effluent quality objectives which the owner is obligated to use best efforts to strive towards on an ongoing basis. It is the Ministry's experience that the setting of such objectives coupled with the bona fide efforts of an owner to achieve them tends to assist an owner in complying with the generally less stringent effluent requirements contained in Condition 3.1, thereby serving the environmental goals set out in the reason for the latter condition.

Conditions 4.1 to 4.6 and 5.1 are included to require the Owner to demonstrate on a continual basis that the quality and quantity of the effluent from the approved sewage works is consistent with the design objectives and effluent limits specified in the certificate and that the approved sewage works does not cause any impairment to the receiving watercourse.

Condition 6.1 is included to ensure that a comprehensive Management Program is undertaken.

You may by written notice served upon me and the Environmental Appeal Board within 15 days after receipt of this Notice, require a hearing by the Board. Section 101 of the Ontario Water Resources Act, R.S.O. 1990, Chapter 0.40, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.



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The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the sewage works are located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary,
Environmental Appeal Board,
112 St. Clair Avenue West,
Suite 502,
Toronto, Ontario.
M4V 1N3

AND

The Director,
Section 53, Ontario Water Resources Act,
Ministry of the Environment,
250 Davisville Avenue, 3rd Floor,
Toronto, Ontario.
M4S 1H2

The above noted sewage works are approved under Section 53 of the Ontario Water Resources Act.

DATED AT TORONTO this 10th *day of* July, 1992.

T.D. Armstrong, P. Eng.
Director
Section 53
Ontario Water Resources Act

RC/gw

cc:-Mr. W. Scott, MOE NW, Reg. Dir.
-Mr. John Barr, Kenora District Office, MOE

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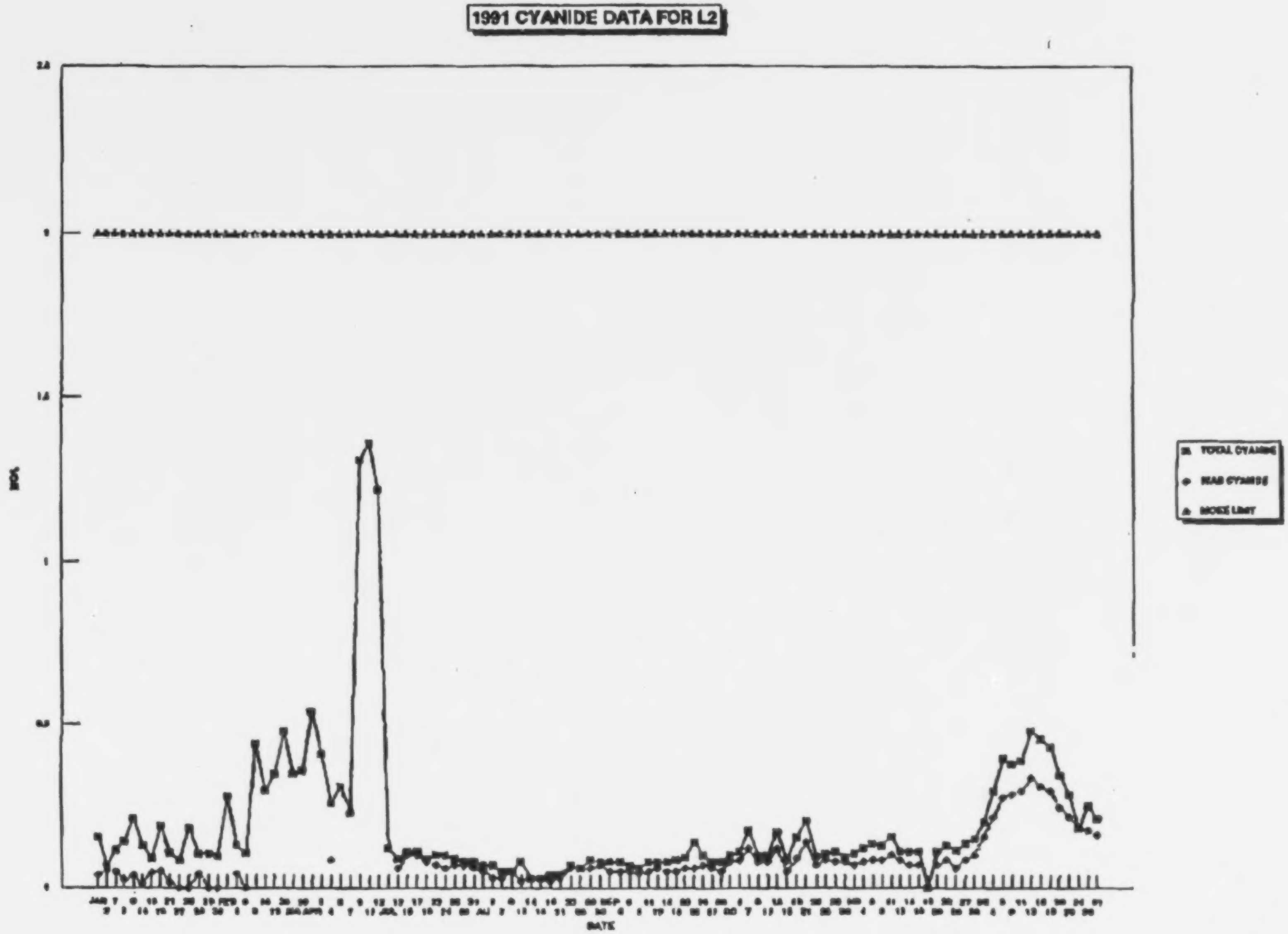
Schedule "A"

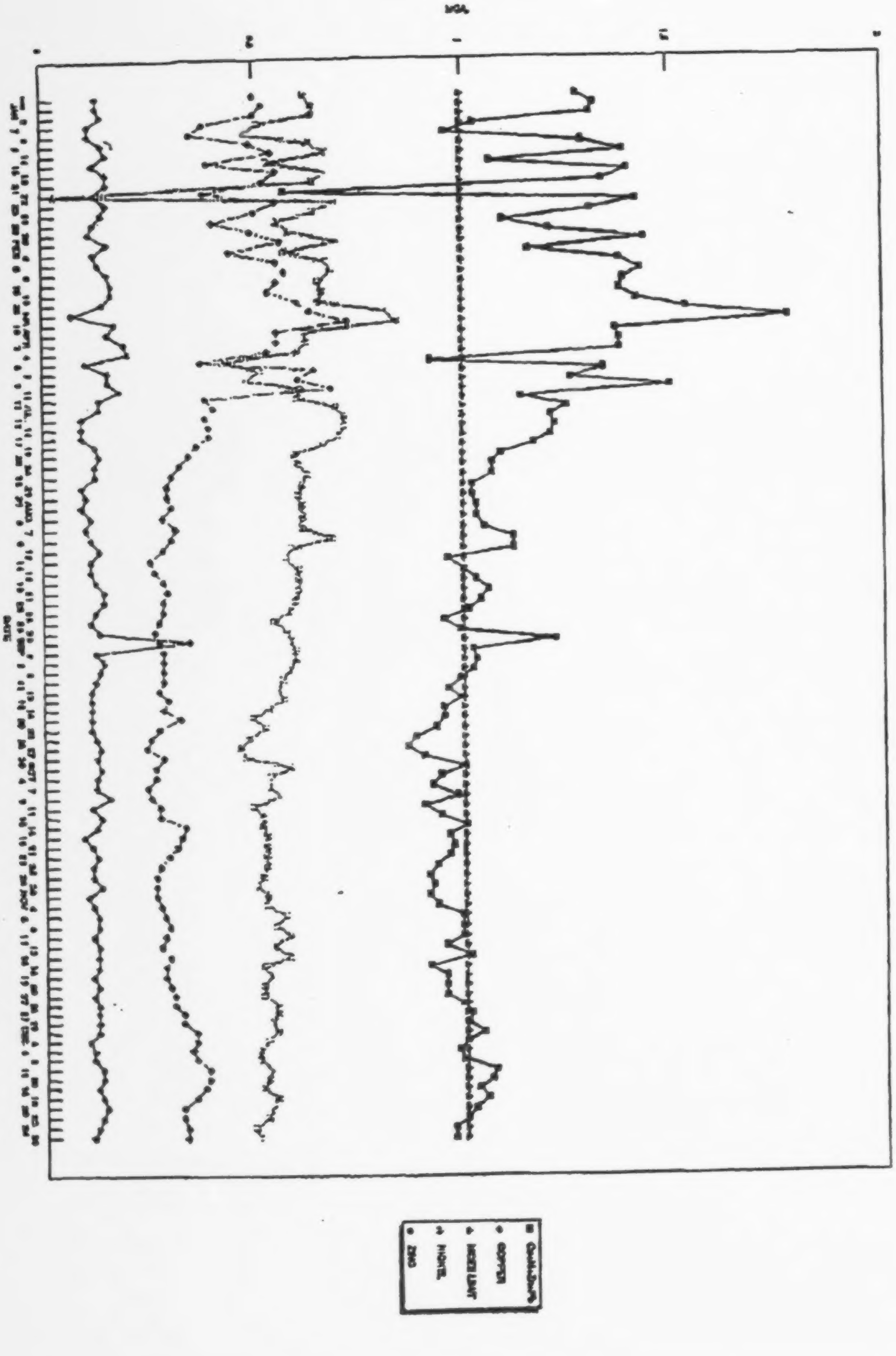
This Schedule "A" forms part of the Certificate of Approval No. 4-058-86-928 and is a list of information received and relied upon in the issuance of this approval.

1. Letter submitted by Mr. Tim Mann on May 16th, 1991 to Valerie Chort.
2. Letter submitted by Mr. J. D. Robertson on March 11, 1991, re: Additional Engineering Information for the Tailing Pond Design.
3. Report entitled Geotechnical Investigation and design of Containment Facility for Pressure Oxidation Effluent At Campbell Mine prepared by Steffen Robertson and Kirsten (B.C.) Inc. and submitted by J. Robertson, Manager - Environmental Engineering, Placer Dome Inc. on January 14th, 1991.
4. Application for approval of liquid industrial discharges signed by Mr. J. D. Robertson on behalf of Placer Dome Inc., Campbell Mine, dated May 30th, 1990.
5. Application package submitted by Mr. Robertson on May 30th, 1990 including a cover letter, description of process, drawings and the "Metals Stability Testwork Program" report prepared by Rescan for Campbell Mine.
6. Letters submitted by Mr. Robertson of Placer Dome Inc. on March 29th, 1990.
7. Certificate of Approval No. 4-095-81-826 issued in Toronto on December 31, 1982.
8. Application for approval of liquid industrial discharges dated November 26, 1981, plans, drawings, correspondence and reports submitted by Campbell Red Lake Mines Limited.
9. Application for the Approval of Industrial Sewage Works (Interim), Section 24, Ontario Water Resources Act submitted by Mr. Dave Hiller, Sr. Environmental Engineer, Placer Dome Inc. dated March 25, 1992.
10. Effluent Treatment Plant Cost Study - Revision 1 prepared by Wright Engineers Ltd. dated February 1992.
11. Effluent Treatment Project Campbell Mine - Capital Cost Study prepared by Placer Dome Inc. dated March 1992.
12. Drawings: 01-70-0001 to 0005 inclusive prepared by Placer Dome Inc. dated April 1, 1992.

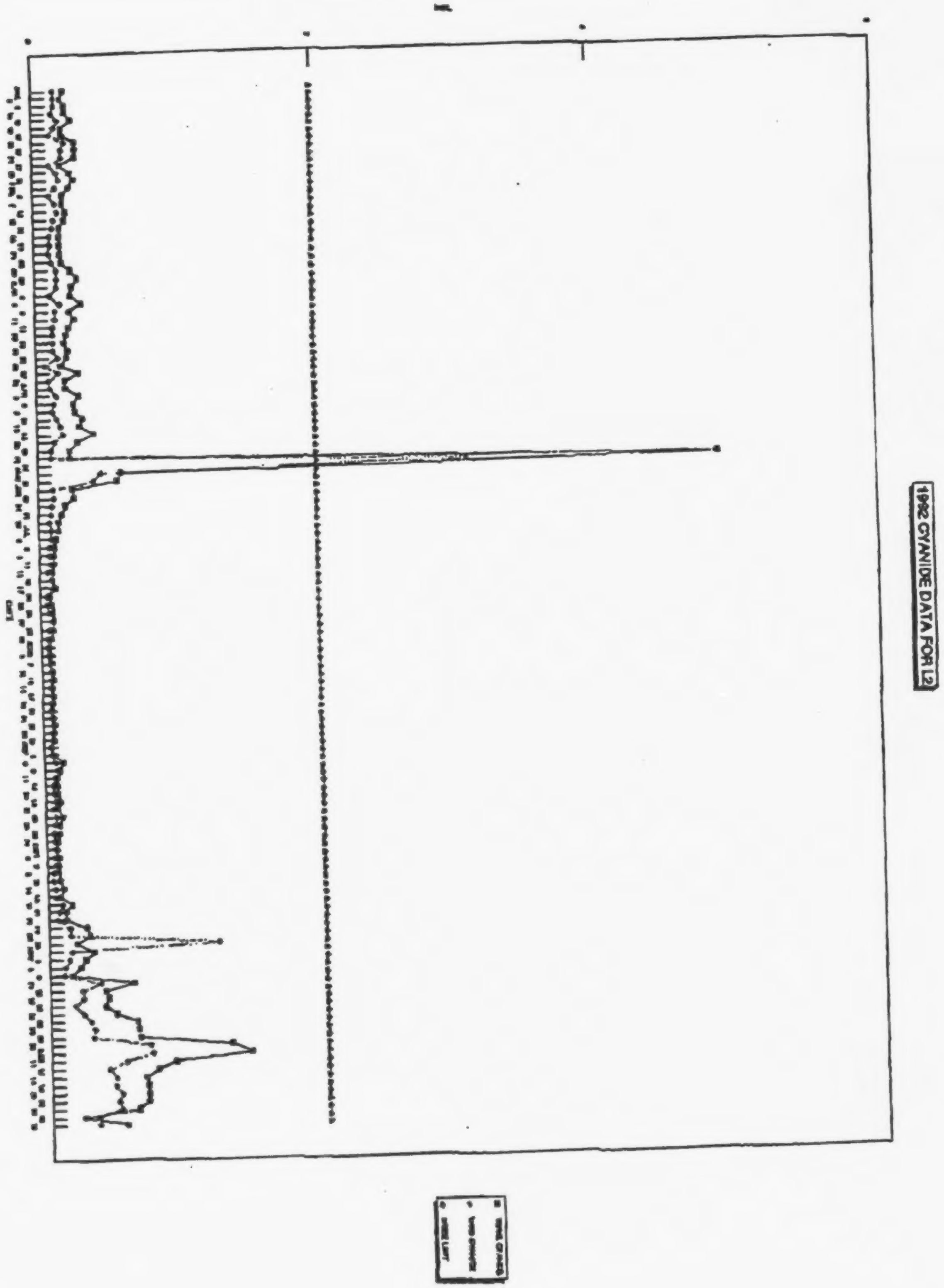
Appendix 4

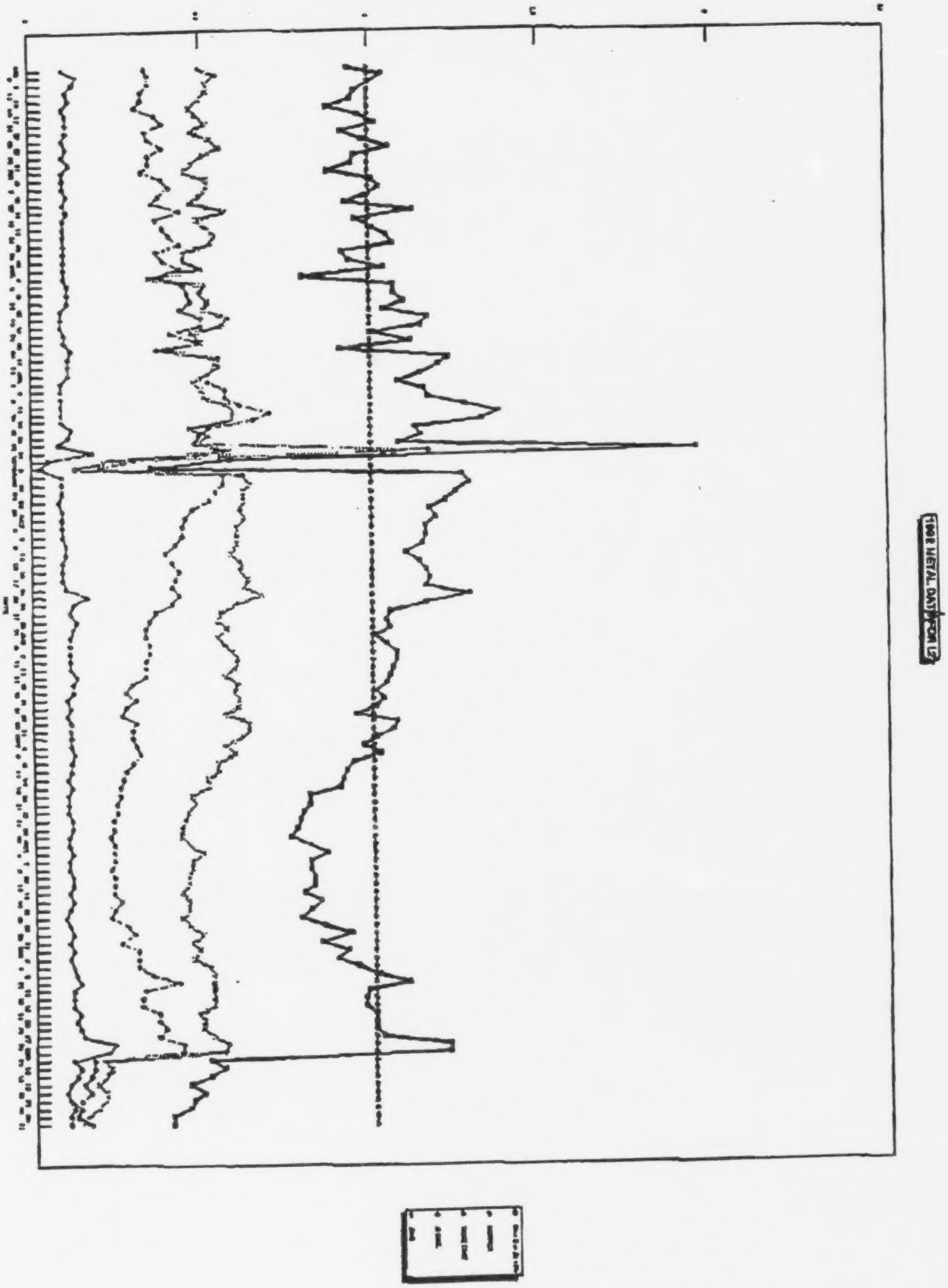
Treated Effluent Data for Red Lake Area Mines

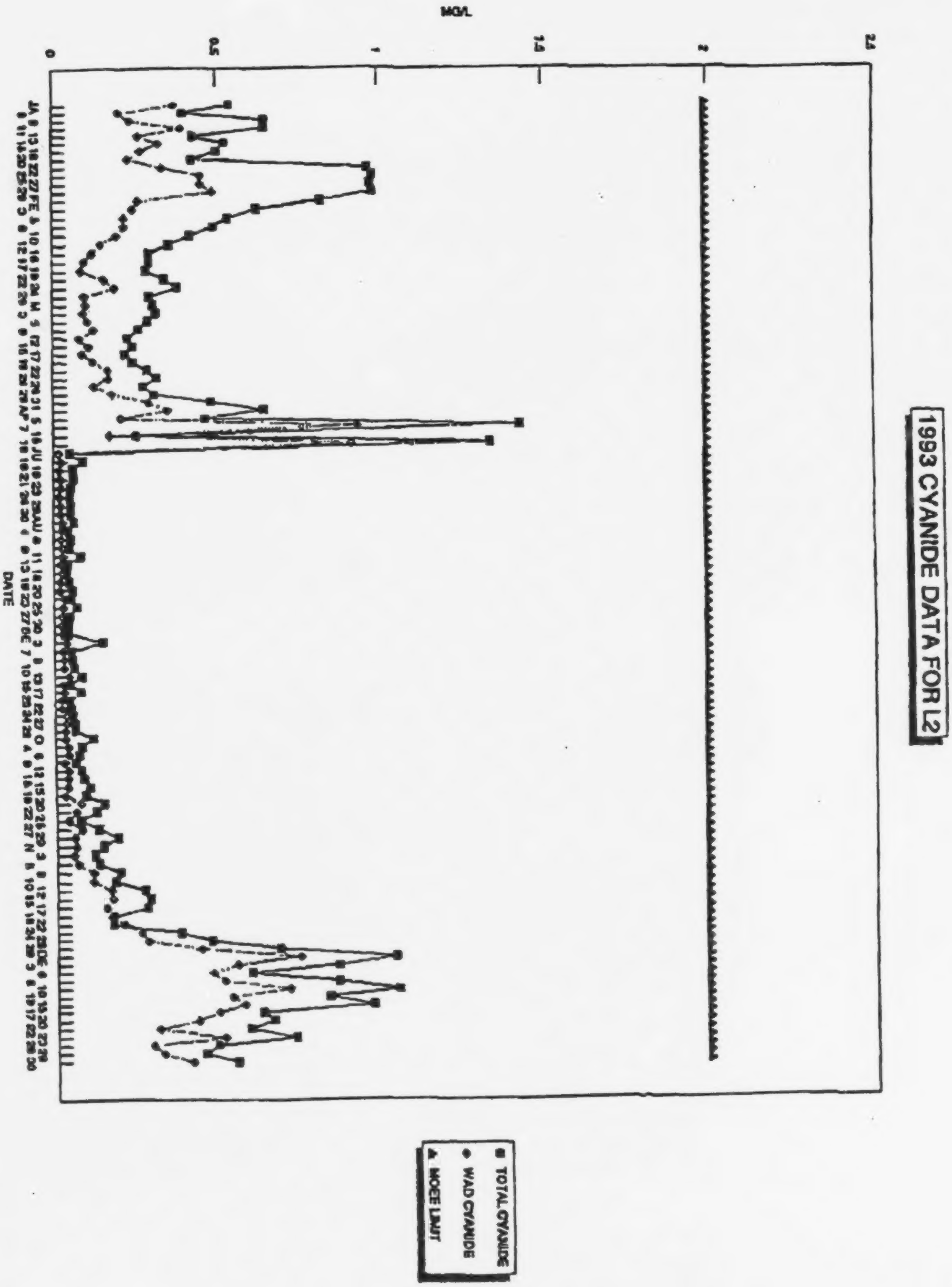

1991 CYANIDE DATA FOR L2
2.5
2
1.5
1
0.5
0
MG/L
DATE
JAN
FEB
APR
JUL
SEP
OCT
■ TOTAL CYANIDE
● WAD CYANIDE
▲ MOEE LIMIT

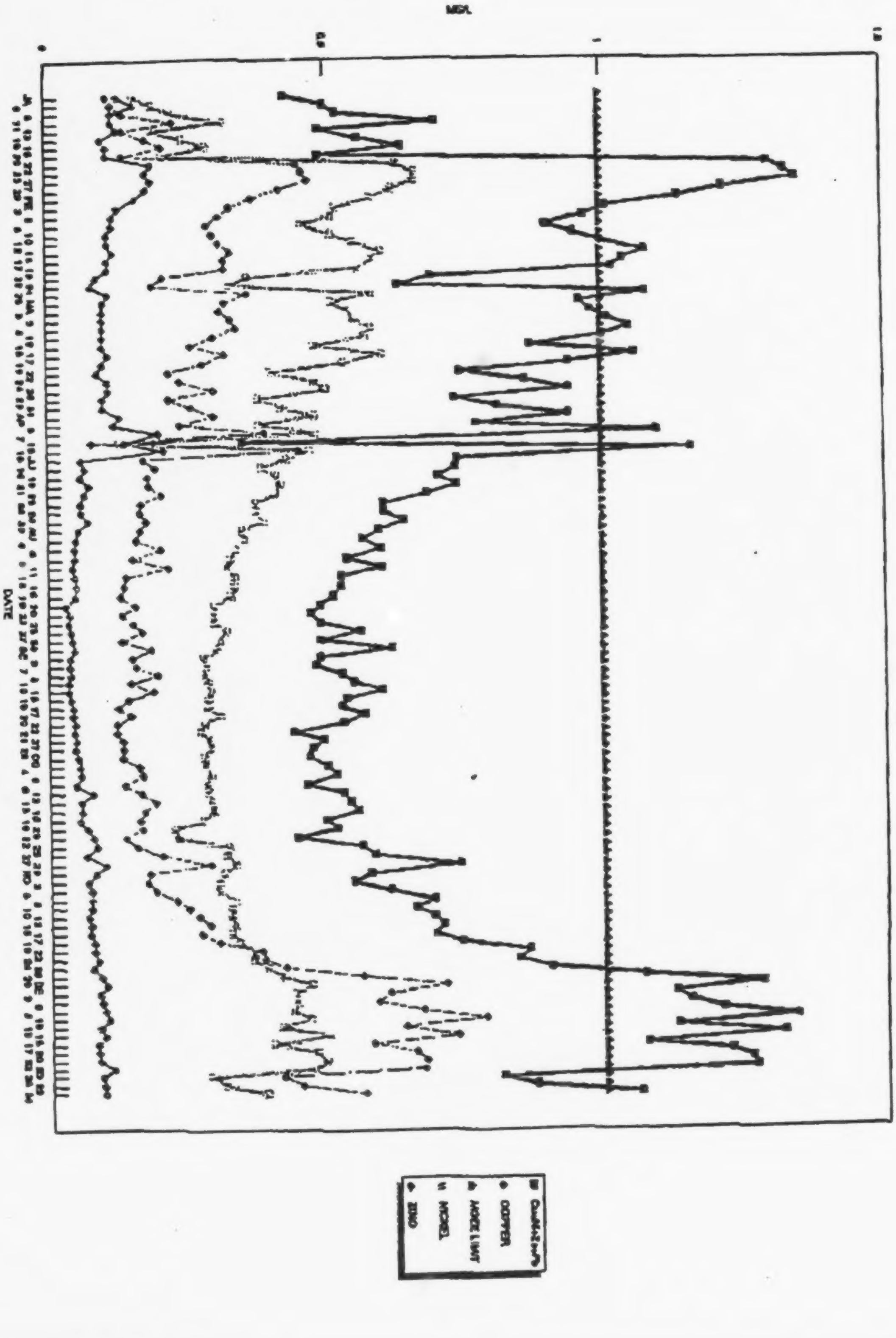


1991 METAL DATA FOR L2

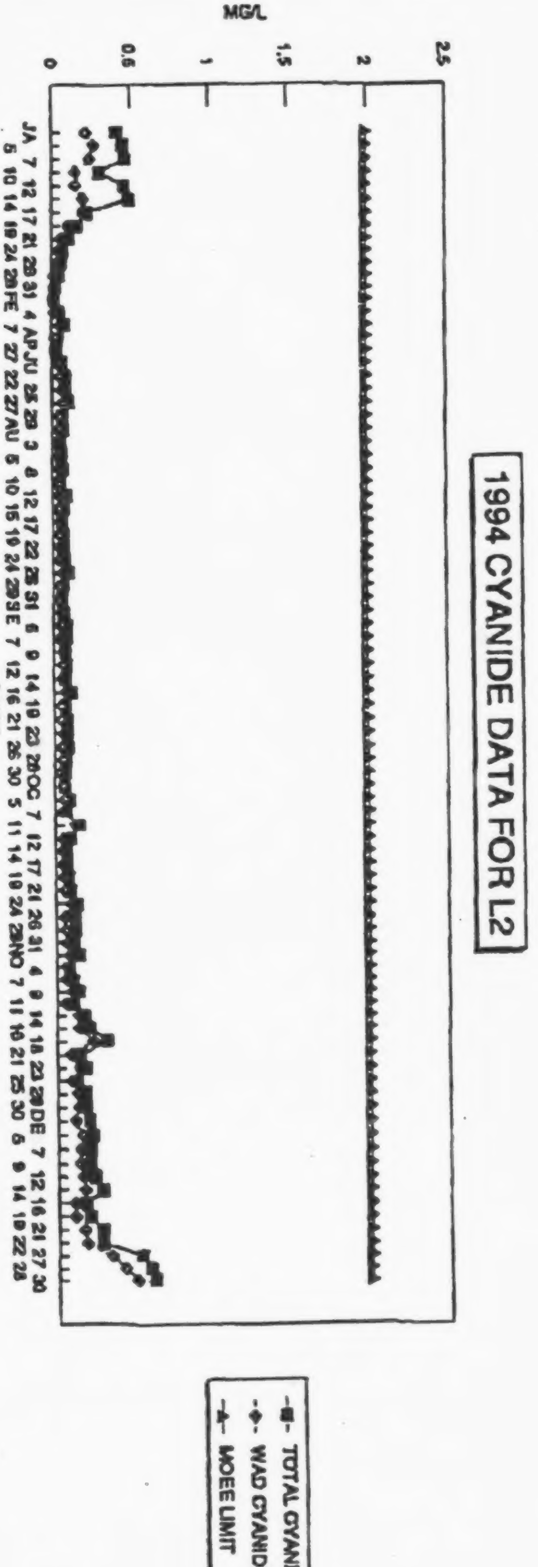

1992 CYANIDE DATA FOR L2

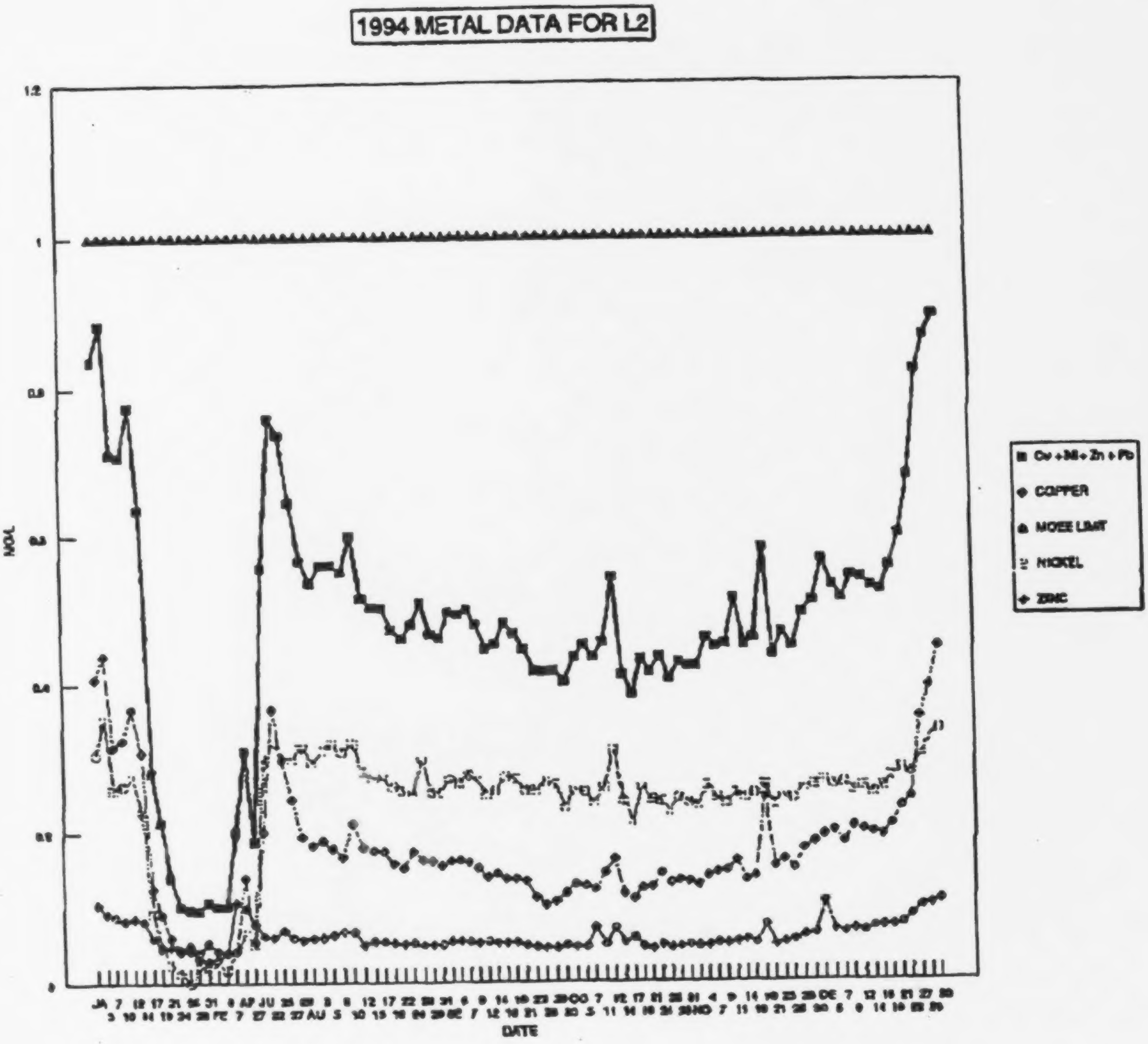

METAL DATA


1993 CYANIDE DATA FOR L2
MG/L
0
0.5
1
1.5
2
2.5
DATE
■ TOTAL CYANIDE
● WAD CYANIDE
▲ MOEE LIMIT



1983 METAL DATA FOR L2


1994 CYANIDE DATA FOR L2
MG/L
2.5
2
1.5
1
0.5
0
JA 7 12 17 21 28 31 4 APJU 25 29 3 8 12 17 22 28 31 6 9 14 19 23 28OC 7 12 17 21 26 31 4 9 14 18 23 28DE 7 12 16 21 27 30
5 10 14 19 24 28FE 7 27 22 27AU 5 10 15 19 24 29SE 7 12 16 21 26 30 5 11 14 19 24 28NO 7 11 16 21 25 30 5 9 14 19 22 28
DATE
TOTAL CYANIDE
WAD CYANIDE
MOEE LIMIT


1994 METAL DATA FOR L2
1.2
1
0.8
0.6
0.4
0.2
0
MG/L
DATE
JA
FE
AP
JU
AU
OC
NO
DE
Cu + Ni + Zn + Pb
COPPER
MOEE LIMIT
NICKEL
ZINC

CONTROL WIER (L2) MONTHLY AVERAGES

L2 1994	FLOW M(3)	SUSPENDED SOLIDS (mg/l)	pH	TOTAL CYANIDE (mg/l)	WAD CYANIDE (mg/l)	TOTAL COPPER (mg/l)	TOTAL NICKEL (mg/l)	TOTAL ZINC (mg/l)	TOTAL LEAD (mg/l)	TOTAL Cu+ Ni+Zn+Pb (mg/l)	TOTAL ARSENIC (mg/l)	TOTAL IRON (mg/l)	NH3 (mg/l)	THIO-CYANATES (mg/l)	HARD NESS	ALK	SO4	TOTAL MERCURY (ug/l)	COND. µmh	TEMP. C	TROL LC5
JANUARY	294.10	10.80	7.54	0.25	0.13	0.189	0.148	0.067	<0.018	<0.430	0.240	1.609	5.87	<0.031	381.1	80.2	226.8	5.8	1125.6	3.0	N.L
FEBRUARY	801	11.47	7.27	0.045	0.029	0.038	0.020	0.064	<0.002	<0.134	0.937	2.759	4.85	<0.031	368.3	57.8	289.8	<0.05	1036.7	3.0	
MARCH	NO DISCHARGE																				
APRIL	5874.30	28.50	7.02	0.04	0.02	0.08	0.07	0.06	0.02	0.14	1.92	0.92	2.98	<0.031	457.4	69.5	258.7		1085.0	8.5	N.L.
MAY	NO DISCHARGE																				
JUNE	NO DISCHARGE																				
JULY	65250.8	9.35	7.54	0.09	0.05	0.216	0.289	0.088	<0.017	<0.588	0.180	0.200	2.45	<0.031	400.3	47.3	310.4	<0.1	1093.8	20.1	N.L
AUGUST	61710.7	5.83	7.13	0.088	0.043	0.173	0.281	0.056	<0.002	<0.612	0.175	0.140	1.88	<0.031	446.8	45.8	335.3	<0.1	1180.0	18.1	N.L
SEPTEMBER	41618.9	6.43	7.65	0.08	0.05	0.136	0.281	0.051	0.006	<0.454	0.183	0.158	1.37	<0.031	476.8	43.0	354.8	<0.1	1228.9	14.8	N.L
OCTOBER	67842.4	8.2	7.3	0.088	0.061	0.181	0.247	0.052	0.002	<0.432	0.205	0.837	1.80	<0.031	478.2	41.8	318.1	<0.1	1227.3	8.8	N.L
NOVEMBER	78273.3	14.80	7.27	0.159	0.111	0.156	0.247	0.054	<0.011	<0.472	0.203	0.790	1.79	<0.031	442.8	41.2	331.5	0.20	1118.4	2.9	N.L
DECEMBER	31575.4	7.71	7.37	0.21	0.21	0.248	0.276	0.081	0.021	<0.628	0.210	0.811	2.08	<0.031	434.5	51.0	330.4	<0.1	1091.8	1.8	N.L
AVERAGE	395293.5	11.41	7.28	0.13	0.08	0.16	0.20	0.06	0.01	<0.42	0.47	0.84	2.70	<0.031	429.47	50.72	308.22	0.85	1129.89	8.76	N.L

[illegible] MONTHLY AVE [illegible]

[illegible]	FLOW (m3)	SUSPENDED SOLIDS (mg/l)	pH	TOTAL CYANIDE (mg/l)	WAD CYANIDES (mg/l)	TOTAL COPPER (mg/l)	TOTAL NICKEL (mg/l)	TOTAL ZINC (mg/l)	TOTAL LEAD (mg/l)	TOTAL Cu+Zn+Pb (mg/l)	TOTAL ARSENIC (mg/l)	TOTAL IRON (mg/l)	NH3 (mg/l)	THIO-CYANATES (mg/l)	HARD-NESS (mg/l)	ALK (mg/l)	SO4 (mg/l)	TOTAL MERCURY (ug/l)	COND. (umh)	TEMP. C	TROUT LC50
JANUARY	119677.8	4.28	7.30	0.246	0.164	0.56	0.61	0.11	<0.03	<1.06	0.651	0.69	1.32	0.34	214.3	60.4	161.3	0.70	638.9	0.6	N.L.
FEBRUARY	91034.4	4.10	7.31	0.010	0.127	0.39	0.46	0.10	<0.03	<1.07	0.713	0.85	1.70	0.94	232.7	58.9	141.8	<0.02	644.8	0.0	>100%
MARCH	79448.2	0.62	7.28	0.230	0.128	0.48	0.50	0.10	<0.03	<1.10	0.480	0.86	2.44	0.91	243.66	63.41	145.77	0.04	666.1	0.0	>100%
APRIL	81127.7	6.11	7.37	0.310	0.530	0.54	0.46	0.11	<0.03	<1.14	0.771	0.79	2.38	1.78	223.42	66.75	161.89	0.03	646.9	0.0	N.L.
MAY	37451.4	8.86	7.09	1.090	0.700	0.48	0.44	0.12	<0.03	[illegible]	0.386	1.10	4.17	2.07	77.00	14.50	85.00		182.5	3.3	
JUNE	48468.3	5.19	7.41	0.385	0.128	0.66	0.60	0.10	<0.03	[illegible]	0.386	0.81	4.18	0.84	260.7	61.7	128.5	0.03	668.0	17.7	>100%
JULY	88757.8	0.48	7.31	0.080	0.066	0.40	0.60	0.11	<0.03	<1.14	0.308	0.30	1.10	0.76	239.8	33.9	213.5	<0.02	694.5	17.7	N.L.
AUGUST	70753.7	3.16	7.48	0.066	0.080	0.31	0.38	0.11	<0.03	<1.05	0.280	0.80	0.58	0.72	255.8	31.2	241.9	<0.02	698.0	19.8	N.L.
SEPTEMBER	88553.7	8.28	7.49	0.080	0.080	0.29	0.40	0.11	<0.03	<0.96	0.300	0.86	0.67	0.69	240.1	32.7	230.5	<0.05	638.4	9.7	N.L.
OCTOBER	96540.3	0.47	7.43	0.134	0.102	0.24	0.49	0.10	<0.03	<1.02	0.273	0.72	0.80	1.02	256.8	34.2	187.1	0.01	654.4	3.6	N.L.
NOVEMBER	29828.9	7.02	7.41	0.481	0.257	0.36	0.81	0.13	<0.03	<1.01	0.343	0.86	1.06	1.83	261.0	38.9	228.9	<0.05	740.7	0.6	N.L.
DECEMBER	7028.6	8.48	7.52	0.74	0.61	0.17	0.26	0.13	<0.03	<0.88	0.22	1.26	2.86	1.44	351.8	48.6	220.0	<0.05	1061.7	0.9	N.L.
AVERAGE	47804.1	5.74	7.38	0.34	0.25	0.45	0.48	0.11	<0.03	<1.02	0.42	0.88	2.10	1.11	233.75	42.77	178.97	<0.07	656.33	6.2	

CONTROL WEIR (L2) MONTHLY AVERAGES 1995

	FLOW	SUSPENDED	pH	TOTAL	WAD	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL Cu+	TOTAL	TOTAL	NH3	THIO-	HARD-			TOTAL	COND.	TEMP.	TROUT
L2		SOLIDS		CYANIDE	CYANIDE	COPPER	NICKEL	ZINC	LEAD	Ni+Zn+Pb	ARSENIC	IRON		CYANATE	NESS	ALK	SO4	MERCURY			LC50
1995	M3	(mg/l)		(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)				(ug/l)	umh	C	
FEBRUARY	5960.0	4.8	7.86	0.43	0.17	0.30	0.61	0.11	<0.03	0.83	0.21	0.70	2.7	1.6	330.8	38.8	225.0	<0.05	829.0	0.0	N.L.
MARCH	12025.7	6.5	7.90	0.28	0.13	0.29	0.61	0.10	<0.03	0.90	0.30	0.90	2.7	0.9	332.3	40.0	280.0	<0.05	851.7	0.0	N.L.
APRIL	6276.7	16.9	7.58	0.63	0.56	0.21	0.29	0.13	<0.03	0.63	0.30	1.81	4.6	1.5	327.8	43.0	230.7	<0.05	881.8	2.2	N.L.
MAY	NO DISCHARGE	8.0	7.73	0.50	0.28	0.28	0.34	0.12	<0.03	0.74	0.23	0.98	4.4	1.1	371.3	82.5	272.8	<0.05	987.5	8.8	
JUNE	NO DISCHARGE	7.1	7.52	0.89	0.56	0.48	0.45	0.19	<0.03	1.07	0.30	0.80	4.1	2.4	360.0	84.0	294.0	<0.05	937.0	8.0	
JULY	55880.4	7.7	7.70	0.08	0.02	0.18	0.39	0.08	<0.03	0.83	0.18	0.28	1.3	<0.001	304.8	42.2	267.9	0.4	849.0	19.0	N.L.
AUGUST	62236.0	3.4	7.59	0.05	0.02	0.16	0.32	0.04	0.01	0.50	0.19	0.24	1.0	<0.001	271.3	69.1	310.0	<0.12	790.4	19.8	N.L.
SEPTEMBER	80168.3	10.1	7.81	0.08	0.03	0.15	0.29	0.04	0.05	0.52	0.21	0.36	1.0	<0.001)	295.9	91.0	218.8	2.8	1038.1	11.8	N.L.
OCTOBER	59567.8	8.5	7.87	0.10	0.04	0.17	0.28	0.08	0.01	0.50	0.22	0.89	1.2	<0.03)	375.2	44.3	251.4	2.0	848.1	4.8	N.L.
NOVEMBER	32145.0	8.7	7.45	0.27	0.17	0.36	0.34	0.07	<0.03	0.71	0.22	0.69	1.42	0.018	361.6	46.6	220.3	1.0	879.0	1.7	N.L.
DECEMBER	10199.1	9.8	7.44	0.74	0.49	0.62	0.43	0.09	0.02	1.16	0.32	0.84	3.18	0.09	392.1	82.3	234.1	0.8	1070.4	1.0	N.L.
AVERAGE	31117.9	8.5	7.8	0.4	0.2	0.3	0.4	0.1	<0.03	0.7	0.3	0.7	2.5	0.7	335.8	52.4	250.5	0.8	920.5	7.1	N.L.